



INDIAN AGRICULTURAL  
RESEARCH INSTITUTE, NEW DELHI.

**I. A. R. I. 6.**

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**TRANSACTIONS**  
**AND**  
**PROCEEDINGS**  
**OF THE**  
**ROYAL SOCIETY OF NEW ZEALAND**

**VOL. 69**

**EDITED AND PUBLISHED UNDER THE AUTHORITY OF THE COUNCIL  
OF THE ROYAL SOCIETY OF NEW ZEALAND**

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## ROYAL SOCIETY OF NEW ZEALAND.

### NOTICE TO MEMBERS.

THE publications of the Royal Society of New Zealand consist of—

1. *Transactions*, a yearly volume of scientific papers read before the local Member-bodies. This volume is of royal-octavo size.
2. *Proceedings*, containing report of the annual meeting of the Council of the Royal Society of New Zealand, list of members, etc. The *Proceedings* are incorporated with the quarterly numbers of *Transactions* supplied to members.
3. *Bulletins*. Under this title papers are issued from time to time which for some reason it is not possible to include in the yearly volume of *Transactions*. The bulletins are of the same size and style as the *Transactions*, but appear at irregular intervals, and each bulletin is complete in itself and separately paged. The bulletins are not issued free to members, but may be obtained by them at a reduction on the published price.

**LIBRARY PRIVILEGES OF MEMBERS.**—Upon application by any member to the Librarian of the Royal Society of New Zealand or of any of the member-bodies, such works as he desires to consult which are in those libraries will be forwarded to him, subject to the rules under which they are issued by the Society or member-body. The borrower will be required to pay for the carriage of the books. For a list of the serial publications received by the Library of the Royal Society of New Zealand, see vol. 64, pp. 455-465.

**ADDRESSES OF MEMBERS.**—Members are requested to notify the Secretary of any change of address, so that the same may be noted in the List of Members.

# INSTRUCTIONS TO AUTHORS OF PAPERS

THE attention of authors is particularly directed to the following instructions, the observance of which will greatly aid the work of both Editor and printer.

1. All papers must be typewritten, unless special permission to send in written papers has been granted by the Editor for the time being. Wide spacing between the lines and ample margin should be left.

2. The author should read over and correct the copy before sending it to the Editor of the *Transactions*.

3. A badly arranged or carelessly composed paper will be sent back to the author for amendment. It is not the duty of an editor to amend either bad arrangement or defective composition.

4. In regard to underlining of words, it is advisable, as a rule, to underline only specific and generic names, titles of books and periodicals, and foreign words.

5. In regard to specific names, the International Rules of Zoological Nomenclature and the International Rules for Botanical Nomenclature must be adhered to.

6. Titles of papers should give a clear indication of the scope of the paper, and such indefinite titles as, *e.g.*, "Additions to the New Zealand Fauna" should be avoided.

7. Papers should be as concise as possible, and the number of figures should be strictly limited.

8. Photographs intended for reproduction should be the best procurable prints, sent flat.

9. *Line Drawings*.—Drawings and diagrams may be executed in line or wash. If drawn in line—*i.e.*, with pen and ink—the best results are to be obtained only from good, firm, black lines, using such an ink as Higgin's liquid India ink, or a freshly mixed Chinese ink of good quality, drawn on a smooth surface, such as Bristol board. Thin, scratchy, or faint lines must be avoided. Bold work, drawn to about twice the size (linear) of the plate, will give the best results. Tints or washes may not be used on line drawings, the object being to get the greatest contrast from a densely black line drawn on a smooth white surface.

10. *Wash Drawings*.—If drawing in wash is preferred, the washes should be made in such water-colour as lamp-black, ivory black, or India ink. These reproduce better than a neutral tint, which inclines too much to blue in its light tones. High lights are better left free from colour, although they may be stopped out with Chinese white. As in line drawings, a fine surface should be used (the grain of most drawing-papers reproduces in the print with bad effect), and well-modelled contrasted work will give satisfactory results.

## *Instructions to Authors of Papers.*

11. *Size and Arrangement of Drawings.*—The printed plate will not exceed 7½in by 4½in, and drawings for plates may be to this size, or preferably a multiple thereof, maintaining the same proportion of height to width of plate. When a number of drawings are to appear on one plate they should be neatly arranged, and if numbered or lettered in soft pencil the printer will mark them permanently before reproduction. In plates of wash drawings, all the subjects comprising one plate should be grouped on the same sheet of paper or cardboard, as any joining-up shows in the print. Text-figures should be drawn for reduction to a width not exceeding 4½in. If there are a number of small text-figures they should be drawn all for the same reduction, so that they may be arranged in groups. In the case of plates composed of a number of separate figures, the latter should be arranged *by the author* in groups of appropriate dimensions. Alternatively, exact instructions as to proposed arrangement of figures should be included with the MS.

12. *Maps.*—A small outline map of New Zealand is obtainable at a low price from the Lands and Survey Department, Wellington, upon which details of distribution, etc., can be filled in according to the instructions given above for line drawings.

13. *Citation.*—References may be placed in a list at the end of an article or arranged as footnotes. The former method is preferable in long papers. In the list references must be arranged alphabetically, reference in the text being made by writing after the author's name, as it occurs, the year of publication of the work, adding, if necessary, a page number, and enclosing these in parentheses, thus: "Benham (1915, p. 176)." Example of forms of citation for alphabetical list:

BENHAM, W. B., 1915. Oligochaeta from the Kermadec Islands. *Trans. N.Z. Inst.* vol. 47, pp. 174-285.

PARK, J., 1910. *The Geology of New Zealand*, Christchurch, Whitecombe and Tombs.

When references are not in alphabetical order the initials of the author should precede the surname, and the year of publication should be placed at the end. Care should be taken to verify the details of all references—date, pages, etc.—and initials of authors should be given.

14. In accordance with a resolution of the Council, authors are warned that previous publication of a paper may militate against its acceptance for the *Transactions*.

15. *Reprints.*—In ordinary cases twenty-five copies of each paper are supplied gratis to the author, and in cases approved of by the Publication Committee fifty copies may be supplied without charge. Additional copies may be obtained at cost price. [The present rate is 1s 3d per page for 100 extra copies; thereafter 3d per page for each additional 25 copies.]

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# PROCEEDINGS

## OF

### THE ROYAL SOCIETY OF NEW ZEALAND

#### MINUTES OF THE ANNUAL MEETING OF THE COUNCIL, 23rd MAY, 1939.

THE Annual Meeting of the Council was held on Tuesday, 23rd May, 1939, commencing at 10 a.m., in the Council Room of Victoria University College, Wellington.

*Roll Call:* The Secretary called the roll, the following being present:—

The President (Professor W. P. Evans), the Vice-President and Co-opted Member (Dr. P. Marshall);

Representing the Government: Mr. B. C. Aston, Professor E. R. Hudson and Dr. W. R. B. Oliver;

Representing Auckland Institute: Mr. G. Archey and Professor H. W. Segar;

Representing Wellington Branch: Dr. H. H. Allan and Mr. F. R. Callaghan;

Representing Canterbury Branch: Dr. F. W. Hilgendorf and Mr. E. F. Stead;

Representing Otago Branch: Dr. C. M. Focken and Mr. G. Simpson;

Representing Hawke's Bay Branch: Mr. G. V. Hudson;

Representing Manawatu Branch: Mr. M. A. Elliott;

Representing Nelson Institute: Sir Thomas Easterfield.

*Apologies:* Apologies for absence were received from His Excellency the Governor-General and the Hon. Minister for Scientific and Industrial Research.

*New Members:* The President welcomed Dr. C. M. Focken and Mr. G. Simpson, who had been appointed to represent the Otago Branch in place of Professor J. Park and Dr. F. J. Turner, who had resigned. He paid a tribute to Professor Park, making reference to his long service on the Council, and to Dr. Turner, who had done such good work as Editor of the *Transactions*.

*Presidential Address:* Professor Evans then read his Presidential Address, in which he first made reference to the loss the Society had sustained by the death of Dr. J. S. Maclaurin, a Fellow of the Society, and Dr. W. J. Mellor, an Honorary Member of the Society since 1919.

At the conclusion of the address, on the motion of Dr. Marshall, Professor Evans was heartily thanked, and was asked to allow his address to be printed in the *Transactions*.

*Hector Award:* The President read the report of the Hector Award Committee as follows:—

The Committee appointed to consider the award of the Hector Medal and Prize has unanimously decided that it should be awarded to Professor J. A. Bartrum, of the Geology Department of Auckland University College.

P. MARSHALL, Convener.

22nd May, 1939.

On the motion of Dr. Marshall, the Hector Medal and Prize were awarded to Professor Bartrum.

*Amount of Hector Prize:* On the motion of Mr. Elliott, seconded by Mr. Archey, it was resolved that the amount of the Hector Prize be £50.

*Honorary Members:* An election to fill the four vacancies which had occurred in the Honorary Members' list was held, and resulted in Dr. J. A. Fleming, Dr. E. J. Butler, and Sir Robert Robinson being elected. There was a tie for the fourth vacancy, and as a result of a second ballot, Sir Arthur Keith was elected.

*Declaration of Vacancies:* One vacancy in the Honorary Members' list caused by the death of Dr. W. J. Mellor was declared, and it was decided to fill this vacancy at the next annual meeting.

*Fellows:* The President read the report of Professor Kirk, Convener of the Fellowship Selection Committee, as follows:—

I have to report that the Fellowship Selection Committee decided to recommend for appointment as Fellows of the Society: Dr. Harold John Finlay, Dr. Henry Oscar Askew.

H. B. KIRK, Convener.

Professor Evans moved, and Sir Thomas Easterfield seconded: "That Dr. Finlay and Dr. Askew be elected Fellows of the Royal Society of New Zealand."—Carried.

*Declaration of Vacancies:* One new vacancy caused by the death of Dr. J. S. MacLaurin was announced. It was decided to elect two Fellows in 1940.

*Member Bodies' Reports:* It was reported that the reports and balance sheets of all the Member Bodies had been received, and these were referred to the Hon. Treasurer for report.

REPORT OF THE STANDING COMMITTEE FOR THE YEAR ENDING 31ST MARCH, 1939.

*Meetings:* Eight meetings of the Standing Committee were held during the year, the attendance being as follows:—Professor Evans, Wellington, 8; Mr. G. V. Hudson, Wellington, 8; Dr. P. Marshall, Wellington, 7; Dr. H. H. Allan, Wellington, 7; Mr. F. R. Callaghan, Wellington, 6; Dr. E. Marsden, Wellington, 4; Mr. B. C. Aston, Wellington, 2; Dr. W. R. B. Oliver, Wellington, 2; Mr. G. Archey, Auckland, 1.

*Leave of Absence:* In February leave of absence was granted to the Hon. Treasurer, Mr. M. A. Elliott, who intended to visit Australia. Dr. Oliver returned from abroad in November.

*Publication Matters:* Parts 1, 2 and 3 of Volume 68 have been published, and Part 4 should be out before the Annual Meeting is held. The material for Part 1 of Volume 69 is also in the printers' hands.

The first part of Volume 68 contained the obituary notice of Lord Rutherford, written by Dr. Marsden, and a bibliography compiled by Dr. Focken. It contained, also, two coloured plates of six figures showing the fruit colour in F2 *Coprosma* hybrids. These plates were satisfactorily produced by the Otago Daily Times Company.

*Printing:* After some consideration of the tender of another firm of printers, the Standing Committee decided to adhere to the Otago Daily Times Company as printers of the *Transactions*.

*Scientific Bibliography:* As instructed by the Annual Meeting, the Standing Committee wrote to the Centennial Historical Committee and asked if it would be prepared to print a bibliography of New Zealand scientific books and papers if prepared by the Royal Society. In due course a reply was received to the effect that owing to the heavy programme of centennial publications already undertaken the printing of the proposed bibliography could not be undertaken.

*Scientific Reviews:* At a meeting of the Standing Committee on the 7th June consideration was given to the best method of carrying out the instruction of the Annual Meeting to publish scientific reviews in the *Transactions*, and it was decided to ask the Fellowship Selection Committee, being a representative committee of the various sciences, with the addition of the Vice-President, Dr. P. Marshall, to select the subjects to be reviewed and the persons to review them.

A suggestion was made that the Society might prepare and publish in the *Transactions* a scientific survey up to the present time as an introduction to the proposed scientific reviews.

*Finances:* The grant received from the Government was the same as last year, namely, £750. The levy on Volume 67 amounted to £190, and sales of publications to £32. This latter amount, in accordance with a resolution of last Annual Meeting, has been placed to the credit of the Endowment Fund.

*Library:* The Library is growing very rapidly, and to be effectively housed requires almost twice as much space as it has at present. The accommodation available in the new Biology Building will be little more than in the present room, so the situation in regard to congestion will not be greatly relieved.

In order to make a small amount of additional space in the present room the Meteorological Section in the Library was transferred to the Meteorological Department on loan. This section was very rarely used by members, and it may be of use in the Department. Possibly a similar action could be taken with the Engineering Section in the Library, although only as a last resource.

The Library is being widely used through the development of the inter-loan scheme, many requests for books from other libraries having been received.

*Binding:* A binder whose charges are higher than the previous binder's charges, but lower than the estimates received from the local book-binding firms, has undertaken to do as much binding as the Society can afford. There is an

amount of £126 in the Library Fund for this purpose, and as the Standing Committee some time ago gave authority for this amount to be expended, the work is being proceeded with at once.

*Member-Bodies' Reports:* The following reports and balance sheets have been received:—

Wellington Philosophical Society for the year ended 30th September, 1938.

Canterbury Branch for the year ended 31st October, 1938.

Otago Branch for the year ended 31st October, 1938.

Nelson Institute for the year ended 31st December, 1938.

*Southland Branch:* On the 4th July the Director of the Southland Museum (Mr. J. H. Sorensen) wrote stating that an endeavour was being made to form a Southland Branch of the Royal Society of New Zealand, with headquarters at Invercargill, and that he and Dr. Uttley were convening a meeting for that purpose. He asked for a ruling as to whether the Society, when formed, could at once adopt the title "Southland Branch" of the Royal Society of New Zealand."

The Standing Committee replied that there could be no objection provided the rules set down for Member-Bodies were complied with, although no certificate of admission could be given for twelve months after formation.

The Standing Committee expressed its pleasure that the Southland Society was being re-established.

*Fellowship R.S.N.Z.:* To fill the two vacancies in the Fellowship the Member-Bodies were asked to forward nominations. Fourteen nominations were received and forwarded to the Fellows for selection. The Fellowship Selection Committee will submit its recommendation to the Annual Meeting.

*Honorary Members:* There are four vacancies to be filled in the Hon. Members' List, and ten nominations have been received from the Member-Bodies. These nominations are being submitted to Members of the Council, and the election will take place at the Annual Meeting.

*Carter Bequest:* At a meeting of the Standing Committee held on the 12th September, 1938, the Carter Observatory Bill was considered clause by clause and agreed to.

Dr. Marsden was asked to indicate to the Minister in charge of the Bill that the Society would like the three members of the Board to be appointed by the Governor-General, in addition to those appointed by the Government, the City Council, and the Royal Society to be independent members.

Professor Evans then moved: "That provided the Carter Observatory Bill at present before Parliament is passed without substantial alteration or amendment the Standing Committee of the Royal Society of New Zealand, acting upon authority given by the Council at its Annual Meeting in May, 1937, instructs the Managers of its Trust Accounts to take whatever steps are necessary to transfer all moneys and securities belonging to the Carter Bequest and now held in trust by the Royal Society of New Zealand to the Carter Observatory Board as soon as that Board is duly constituted and the names of its members gazetted."

This motion was seconded by Dr. P. Marshall and carried.

The Carter Observatory Act, which differed in no way from the Bill which had been approved came into force on the 14th September, 1938.

The Society was subsequently asked to nominate two of the nine members of the Board provided for in the Act, and at a meeting of the Standing Committee held on 26th October, Dr. E. Kidson and Mr. C. G. G. Berry were nominated for a period of three years.

The personnel of the Carter Observatory Board is as follows:—

Representing the R.S.N.Z.: Dr. E. Kidson and Mr. C. G. G. Berry.

Representing the City Council: Mr. E. P. Norman and Mr. M. F. Luckie.

Representing the Government: Professor D. C. H. Florance, Mr. M. Geddes, Dr. C. E. Adams and Dr. E. Marsden.

In accordance with the foregoing resolution all the funds previously belonging to the Carter Bequest have now been paid over to the Board as follows:—Scrip valued at £12,855, representing capital to the amount of £12,487 8s 5d; cheque for non-transferable stock redeemed by Reserve Bank, £103 15s; cheque for funds lying at credit of Carter Bequest, P.O.S.B. Account, £694 16s 10d, making a total of £13,376 0s 3d.

Mr. M. Geddes has been appointed Director of the Observatory, and has taken up his duties. Plans for the erection of the Observatory are being prepared.

*Hector Award:* The 1938 Hector Medal, which was awarded to the late Bishop Williams, was sent to Mrs. Williams privately, in accordance with her expressed wish.

The 1937 Hector Medal and Prize awarded to Dr. J. R. Hosking had not been presented to him owing to the uncertainty of his return to New Zealand. As Dr. Hosking has now intimated that he will not be returning to New Zealand, the medal has been forwarded to him in London, and in accordance with his instructions the prize money has been sent to his brother, Mr. C. R. Hosking, in Canterbury.

*Hutton Award:* The President, Professor Evans, presented the Hutton Medal to Dr. David Miller on the 2nd November, on the occasion of the Cawthron Lecture, at Nelson.

*Hutton Grant:* An application for a grant of £20 from the Hutton Fund from Mr. L. E. Richdale to cover expenses incurred in the ringing of birds for scientific purposes was recommended to the Annual Meeting for approval.

*Hamilton Award:* At a meeting of the Wellington Philosophical Society held on the 26th October, the President presented the Hamilton Prize to Dr. C. O. Hutton, who had returned to New Zealand.

*Cookayne Memorial Fund:* This fund remains the same as last year except for interest accruing in its P.O.S. Bank Account. No donations to the fund have been received since the 30th November, 1937.

*Medals:* The work of altering the medals was executed by John Pinches, and the new supplies reached Wellington in October. The work was very satisfactorily carried out, the charge on the various funds being as follows:—Hector Fund, £55 6s 4d; Hutton Fund, £49 2s 9d; T. K. Sidey Summer-time Fund, £45 7s 2d.

An effort was again made to have the medals placed on the Customs duty exempted list, but without success, it being ruled that the medals are classified under tariff item as fancy goods.

*Seal:* As under the rules the present seal can be used only until the date of the 1939 Annual Meeting, steps were taken, in accordance with the authority given at last Annual Meeting, to have the wording on the seal altered to make it legally correct.

The President, Professor Evans, submitted a design to the Standing Committee, and it was decided to adopt this in modified form and have the necessary alterations to the seal done locally.

*Professor Skottsberg's Visit:* An event of great interest, especially to botanists, occurred during the year in the visit to New Zealand of Professor Skottsberg, of Goteborg, Sweden.

An invitation to Professor Skottsberg, who was engaged in research in Honolulu, was issued by the University of New Zealand and the Society, and contributions towards the expense of the visit were made by them and by some of the Member-Bodies. The Government provided railway facilities for the visit, and this was greatly appreciated. Arrangements were made for Professor Skottsberg to lecture in the four centres, and Dr. H. H. Allan, who organised the visit, went to Auckland to meet Professor Skottsberg and welcomed him on behalf of the Society.

An account of the whole visit was written by Dr. Allan, and will be published in Part 4 of Volume 68 of the *Transactions*.

The Society is deeply indebted to Dr. Allan for undertaking the organisation of Professor Skottsberg's visit to New Zealand.

*Pacific Science Congress:* In October, 1938, a letter was received from the Hold-Over Committee of the Pacific Science Association stating that the next Pacific Science Congress would probably be held in California in 1939. This was confirmed early in this year, when letters stating that the Congress would be held in San Francisco from the 24th July to the 12th August, 1939, were received. The letters indicated that the Congress would not be on such a lavish scale as that of former Congresses, and that delegates would be expected to provide their own fares to and from the Congress and for the various excursions to be held as well as their accommodation while attending the Congress.

Member-Bodies were asked to forward the names of any members likely to be attending the Congress so that the Society's representatives might be appointed.

*A. & N.Z.A.A.S.:* At a meeting of the Standing Committee held on the 7th June, the President (Professor Evans), the Vice-President (Dr. P. Marshall) and Professor R. Speight were appointed to represent the Society at the Canberra meeting of the Association.

On the 27th February, at a meeting of the Standing Committee, Professor Evans congratulated Dr. Marshall on his election as President-elect of the A. & N.Z.A.A.S.

*N.Z. Science Congress:* The Wellington Philosophical Society intimated in July that it was deemed inadvisable to hold the Science Congress in May, 1939, and it suggested May, 1940, as a suitable date. Subsequently, the actual dates decided upon were 23-28th May, 1940. A decision has not yet been reached as to whether the meetings will be held in the Dominion Museum or Victoria University College.

The Sections to be included in the Congress are as follows:—(1) Physical Sciences (a) Mathematics, Physics, and Astronomy, (b) Chemistry; (2) Geological Sciences including Geography; (3) Biological Sciences (a) Zoology, (b) Botany; (4) Rural Sciences including Agriculture and Forestry; (5) Anthropology and History; (6) Social Sciences including Economics.

*Overseas Meetings:* During the year invitations have been received to the dedication of the Franklin Institute, to the Centenary of the Society of Finland, to the 150th Anniversary of the Linnean Society, to the Seventh International Botanical Congress, Stockholm, July, 1940, to the International Geological Congress, London, 31st July-8th August, 1940, and to the International Congress of Mathematicians, Massachusetts, September, 1940. Member-Bodies were asked to forward the names of any members likely to be attending any of the celebrations.

*Research:* A letter was received from the Carnegie Corporation of New York on the 16th May, 1938, stating that it had been unable to reach a decision regarding the Society's research proposals, but that they were being given careful consideration.

On the 24th August the Standing Committee granted (from a small amount of unused grants) the application of Professor Marples for a grant of £20 to enable him to study the food of the Little German Owl.

*Wild Life Control:* Following on published statements regarding the attitude of the Department of Internal Affairs on matters in connection with Wild Life and correspondence between the Minister of Internal Affairs and Mr. Stead, Mr. R. A. Falla and Mr. G. Archey interviewed the Minister of Internal Affairs and departmental representatives. The result of this interview was reported to the Standing Committee at a meeting on the 19th July, and the matter was referred to the Wild Life Control Committee in order that some constructive proposals might be presented to the Department.

Captain Sanderson, of the Forest and Bird Protection Society, wrote asking the Society's co-operation in opposing the proposal of the Wellington Acclimatization Society to obtain permission from the Minister of Internal Affairs to liberate opossums in forest areas where they had not yet penetrated. This matter was also referred to the Wild Life Control Committee.

Owing to geographical difficulties it was found impossible for this Committee to meet and the views of its members were obtained by correspondence.

Mr. Aston, convener of the Committee, reported to the Standing Committee that the members of the Committee were strongly opposed to the liberation of opossums and it was decided to write to the Government protesting against the proposal of the Acclimatization Society. This was done, and the Minister replied that the views of the Society would receive careful consideration.

In regard to the larger question of a Biological Survey in New Zealand, Mr. Aston forwarded to the Standing Committee a memorandum drawn up by Mr. Falla and approved by Mr. Archey and Mr. Stead as follows:—

*Suggestions for Organisation of Biological Survey in New Zealand.*

While approving of and supporting the policy of the Government in legislating for the preservation of native flora and fauna and the control of imported plants and animals, this Committee believes that a much fuller scientific inquiry into the complexities and separate aspects of the problem is urgently needed to guide both legislative and administrative action.

In the past it has been found desirable to create and maintain research institutions, either wholly or partially under Government control, in connection with such major industries as agriculture, animal husbandry, forestry and sea fisheries. Matters relating to the rest of the indigenous and introduced plant and animal life have been, in effect, regarded as of recreational and secondary economic importance, and their welfare controlled by Acclimatization Societies and the various Boards connected with national reserves and parks. Although the bodies function under Government supervision there is little provision made for the scientific collection and examination of essential data upon which future legislation and administrative action should be based.

Examples could be quoted if necessary, but it is felt that the inadequacy of our present knowledge and control of wild life problems will be admitted by all. It is also clear from the experience of other countries that there are two possible methods by which the necessary research work can be organised.

The first is the method adopted in the United States, namely, State organisation of biological research. From the original development of "divisions" within the Department of Agriculture an independent Bureau of Biological Survey was founded in 1904. This now comprises its own Divisions of Administration, Public Relations, Wild Life Research, Land Acquisition, Migratory Wild Fowl, and Game Management. The technical staff alone, in 1938, number 250. On a smaller scale a similar organisation could eventually be provided in New Zealand by extension or subdivision of some existing Department such as Scientific and Industrial Research.

The second method, which would not involve the expense of creating a new department, is the co-ordination, direction, and support of existing research workers and institutions. An advance could be made if certain urgent problems were selected and use made of the resources, chiefly personnel, of biological departments of the universities, of museums, of active working sections of the Royal Society of New Zealand, and of horticultural organisations. It seems desirable that one or other of the existing Government departments should adopt, encourage, direct and initiate such investigatory work, but the Committee feels that such details may be outside the scope of its reference at least until the principle is approved.

The above report was referred to the Annual Meeting for consideration.

*Soil Erosion:* The last Annual Meeting urged the Government to set a Royal Commission with scientifically competent personnel to deal with the urgent question of soil erosion. On the 12th September it was reported that the Government had set up a Committee to bring down a report. To this Committee two members of the Council, Professor E. R. Hudson and Dr. H. H. Allan, were appointed.

*Annual Meeting Luncheon:* Following a suggestion by Mr. Archey, the Standing Committee decided that in order to create a wider interest in the Society a luncheon to which members of the Council would each invite as guest a representative citizen would be held on the day of the Annual Meeting and the President would be asked to deliver part of his Presidential Address at the luncheon.

*Museum Management Committee:* At a meeting of the Standing Committee on the 6th May, 1938, Mr. G. V. Hudson and Professor W. P. Evans were nominated to the Museum Management Committee in place of Mr. B. C. Aston, who had resigned, and the late Bishop Williams respectively. The Board of Trustees of the National Art Gallery and Dominion Museum advised on the 2nd August that these nominations had been approved.

*Loder Cup:* For the 1938 award of the Loder Cup the Standing Committee nominated the Forest and Bird Protection Society. The Loder Cup Committee awarded the Cup to Mrs. Knox Gilmer, Wellington.

*Monograph by Vavilov:* The New Zealand Liaison Officer of the Imperial Agricultural Bureau wrote asking if the Society would be prepared to purchase a copy of a Monograph by Vavilov entitled "Theoretical Bases of Plant Breeding" if the Monograph was translated and published.

It was decided to purchase for the Library the proposed translation at a sum not exceeding £5 for the complete set.

On the motion of Professor Evans, seconded by Mr. Stead, the report of the Standing Committee was adopted.

### *Arising Out of the Report:*

*Scientific Reviews:* Professor Evans read the report of the Committee to which this matter had been submitted. The report stated that the Committee had decided to interpret its instructions to refer to overseas publications, whether by New Zealand workers or by others, bearing on Science in New Zealand or on scientific problems of great interest to New Zealand, and it recommended the names of abstractors in Geology, Botany, Zoology, Mathematics, Chemistry, and Physics.

Mr. Archey expressed his doubts about scientific reviews being published in the *Transactions*. He did not consider they were necessary. Mr. Elliott pointed out that the cost of printing the *Transactions* was steadily increasing, and he would discourage printing matter which was of little value.

Dr. Oliver considered that if abstracts were published they should be contained in the *Proceedings*, which should be published as a separate part. Professor Evans stated that, although the Committee had done as it had been requested, all the members of the Committee considered that abstracts would be of little value to readers of the *Transactions*. Dr. Allan spoke in favour of the proposal, which, he said, from a botanist's point of view, would be very useful. Mr. Hudson also supported the proposal.

After some further discussion, and on the recommendation of Dr. Hilgendorf, it was moved by Mr. Archey, seconded by Mr. Stead, and carried: "That scientific reviews should not be published in the *Transactions*, but that the Editor of the *Journal of Science and*

*Technology* be asked if he could make provision for them to be published in that Journal." It was suggested that the names of those recommended as abstractors be handed over to him.

*Carter Bequest*: On the motion of Professor Evans, seconded by Mr. Elliott, it was resolved: "That as the trust originally declared under the will of the late Charles Rooking Carter was discharged by 'The Carter Observatory Act, 1938,' and as the whole of the accumulated funds belonging to that trust have been handed over to the Carter Observatory Board, in which Board the trust is now vested, the whole of Section F.VI—Carter Bequest—as at present printed in the Rules of the Royal Society of New Zealand, be and is hereby deleted."

*Seal*: Professor Evans outlined the action taken in regard to the seal as authorised by the last Annual Meeting, and an impression of the new seal was handed to members for inspection.

On the motion of Professor Evans, seconded by Dr. Marshall, it was resolved: "That Rule 3 of Section C—'Relating to Custody of Property and Common Seal' be rescinded, and that the following Rule be inserted in its place:—

"3. The seal formerly used by the New Zealand Institute, but with the legend thereon deleted, and the legend 'Seal of the Royal Society of New Zealand' substituted therefor, be the common seal of the Society."

*Pacific Science Congress*: On the motion of Mr. Archey, seconded by Mr. Stead, it was resolved to leave the appointment of representatives to the Pacific Science Congress to the Standing Committee to deal with.

#### HON. TREASURER'S REPORT.

The Balance Sheet for the 12 months ending 31st March, 1939, shows a credit of £849 9s as compared with £937 11s 6d on the 31st March, 1938.

*Carter Bequest*: Transfer of Fund: The Carter Observatory Board has been gazetted, and under Section 17 of "The Carter Observatory Act, 1938," the whole of the Bequest has been transferred to the Board under authority of a resolution of the Standing Committee dated 27th February, 1939, as follows: Scrip representing a total of £12,855, accrued interest in the Post Office Savings Bank amounting to £694 16s 10d. A final amount of £193 15s is being transferred to the Board on the 1st April, 1939, this amount not being able to be redeemed by the Reserve Bank on non-transferable stock until that date.

*Transactions*: Volume 67, Part 4, cost. £134 14s 2d; Volume 68, Part 1, £192 5s; Part 2, £173 17s 3d; Part 3, £98 4s 2d. The considerable increase in the cost of printing the *Transactions* is owing to larger Parts and increased cost of printing charged by the Otago Daily Times Company. Formerly text per page was 14s and plates per page 15s 6d, now 15s 6d and 19s 6d respectively, 3s of the additional cost of the latter being incurred by a decision of the Standing Committee to have plates printed on one side of the paper only.

*Endowment Fund*: By a resolution at last Annual Meeting the Endowment Fund profited by £79 12s 5d, and in accordance with that resolution the amount of sales for this year (£32 8s 9d) will be credited to the Fund.

*Medals*: The necessary alteration to the medals was carried out during the year, the actual cost (including duty) on the various medals being as follows:—Hector Medal, £55 6s 4d; Hutton Medal, £49 2s 9d; Sidey Medal, £45 7s 2d.

I again desire to record my appreciation of the manner in which the Secretary has carried out her duties.

M. A. ELLIOTT, Hon. Treasurer.

## THE ROYAL SOCIETY OF NEW ZEALAND.

## STATEMENT OF RECEIPTS AND EXPENDITURE FOR THE YEAR ENDING MARCH 31, 1939.

*Receipts.*

	£	s.	d.
Balance at 31st March, 1938 .. .. .	1,328	17	1
Annual Grant .. .. .	750	0	0
Levy, Volume 67 .. .. .	190	11	0
Sales of Publications .. .. .	32	8	9
Travelling Expenses: Member-Bodies' Share .. .. .	18	12	6
Contribution towards Coloured Plates .. .. .	3	0	0
Refund from General Assembly Library .. .. .	0	14	7
Favourable Exchange .. .. .	1	13	2
Endowment Fund Interest .. .. .	71	14	0
Carter Bequest Interest .. .. .	496	8	7
Hector Memorial Fund Interest .. .. .	53	3	6
Hutton Memorial Fund Interest .. .. .	62	19	1
T. K. Sidey Summer-time Fund Interest .. .. .	22	11	3
Carter Library Legacy Interest .. .. .	9	5	1
Hamilton Memorial Fund Interest .. .. .	2	2	0
Cockayne Memorial Fund Interest .. .. .	6	16	10
Transfers between Trust Accounts and Bank of New Zealand ..	847	13	1
Transfers between Post Office Savings Bank and Bank of N.Z.	800	0	0
	<u>£4,698</u>	<u>10</u>	<u>6</u>

*Expenditure.*

	£	s.	d.
Otago Daily Times Company—Vol. 67 (4), 68 (1. 2) .. .. .	504	7	6
Stationery .. .. .	4	0	10
Salary .. .. .	300	0	0
Petty Cash (Secretary and Editors) .. .. .	10	12	7
Travelling Expenses .. .. .	31	13	9
Typewriter .. .. .	25	0	0
Charges (Audit, Sub. I.S.U., Insurance, etc.) .. .. .	17	5	6
Telephone Charges .. .. .	3	10	0
Research Grant .. .. .	5	0	0
Hutton Research Grant .. .. .	9	0	0
Grant Prof. Skottsborg's Visit and Expenses .. .. .	27	12	6
Hamilton Prize .. .. .	4	0	0
Altering Medals .. .. .	149	16	3
Engraving Medals .. .. .	1	3	0
Carter Bequest Revenue Account to Carter Observatory Board ..	694	16	10
Stamp Duty: Transferring Scrip to Board .. .. .	1	0	0
Transfer to Trust Accounts .. .. .	12	2	6
Transfers between Bank N.Z. and P.O.S.B. .. .. .	800	0	0
Trust Funds paid direct to Accounts .. .. .	644	1	4
Balance as under .. .. .	1,453	7	11
	<u>£4,698</u>	<u>10</u>	<u>6</u>

	£	s.	d.	£	s.	d.
Bank of New Zealand .. .. .	174	13	3			
Less Unpresented Cheque .. .. .	1	0	0			
				173	13	3
Post Office Savings Bank .. .. .				1,273	15	10
Petty Cash in Hand .. .. .				5	18	10
				<u>£1,453</u>	<u>7</u>	<u>11</u>

## THE ROYAL SOCIETY OF NEW ZEALAND.

## STATEMENT OF LIABILITIES AND ASSETS AT MARCH 31, 1939.

*Liabilities.*

	£	s.	d.
Hector Memorial Fund Capital Account .. .. .	1,184	18	1
Hutton Memorial Fund Capital Account .. .. .	1,314	8	6
Hamilton Memorial Fund Capital Account .. .. .	68	8	3
Carter Bequest Capital Account* .. .. .	193	15	0
Carter Library Legacy Capital Account .. .. .	162	19	0
T. K. Sidey Summer-time Fund Capital Account .. .. .	522	16	7
Endowment Fund Capital Account .. .. .	1,265	3	5
Hector Memorial Fund Revenue Account .. .. .	126	0	2
Hutton Memorial Fund Revenue Account .. .. .	295	10	2
Hamilton Memorial Fund Revenue Account .. .. .	1	15	4
Carter Library Legacy Revenue Account .. .. .	50	5	6
T. K. Sidey Summer-time Fund Revenue Account .. .. .	34	19	11
Endowment Fund Revenue Account .. .. .	327	5	0
Cockayne Memorial Fund Revenue Account .. .. .	267	6	3
Research Grants Fund .. .. .	132	0	6
Library Fund .. .. .	126	1	10
Otago Daily Times Company, Ltd. .. .. .	98	4	2
Balance of Assets over Liabilities .. .. .	849	9	0
	<u>£7,019</u>	<u>6</u>	<u>8</u>

\* Note: Carter Bequest Capital Account—£12,487 8s 5d, representing Scrip to the value of £12,855—was handed over to the Carter Observatory Board on the 31st March, 1939, in terms of Section 17 of "The Carter Observatory Act, 1938."

*Assets.*

	£	s.	d.
Inscribed Stock .. .. .	4,621	6	6
Bank of New Zealand .. .. .	173	13	3
Post Office Savings Bank .. .. .	1,273	15	10
Petty Cash in Hand .. .. .	5	18	10
Sundry Debtors .. .. .	61	2	7
Hector Memorial Fund P.O.S.B. Account .. .. .	128	0	2
Hutton Memorial Fund P.O.S.B. Account .. .. .	306	3	2
Hamilton Memorial Fund P.O.S.B. Account .. .. .	72	8	7
Carter Library Legacy P.O.S.B. Account .. .. .	50	10	6
T. K. Sidey Summer-time P.O.S.B. Account .. .. .	59	1	0
Cockayne Memorial Fund P.O.S.B. Account .. .. .	267	6	3
	<u>£7,019</u>	<u>6</u>	<u>8</u>

M. Wood, Secretary.

The Audit Office, having examined the Balance Sheet and accompanying accounts required by law to be audited, hereby certifies them to be correct.

J. H. FOWLER,

Controller and Auditor-General.

THE ROYAL SOCIETY OF NEW ZEALAND.  
REVENUE ACCOUNT FOR THE YEAR ENDING MARCH 31, 1939.

*Expenditure.*

	£	s.	d.
Printing Vol. 67 (4), 68 (1, 2, 3) .. .. .	602	11	8
Stationery .. .. .	4	0	10
Salary .. .. .	300	0	0
Petty Cash .. .. .	10	12	7
Travelling Expenses .. .. .	13	1	3
Charges (Audit, Telephone, Insurance) .. .. .	18	18	0
Professor Skottsberg's Visit .. .. .	27	12	6
Typewriter .. .. .	25	0	0
Transferred from General Account to Endowment .. .. .	50	0	0
Sales 1937/8 credited to Endowment Fund .. .. .	20	12	5
Sales 1938/9 .. .. .	32	8	9
Balance .. .. .	849	0	0
	<u>£1,963</u>	<u>7</u>	<u>0</u>

*Income.*

	£	s.	d.
By Balance, 31st March, 1938 .. .. .	937	11	6
Annual Grant .. .. .	750	0	0
Levy Vol. 67 .. .. .	190	11	0
Trust Funds Administration Expenses .. .. .	0	14	6
Refund from General Assembly Library .. .. .	0	14	7
Publications Sold .. .. .	76	2	3
Favourable Exchange .. .. .	1	13	2
	<u>£1,963</u>	<u>7</u>	<u>0</u>
By Balance .. .. .	£849	0	0

THE ROYAL SOCIETY OF NEW ZEALAND.  
TRUST ACCOUNTS FOR THE YEAR ENDING MARCH 31, 1939.

*Carter Bequest.*

Dr.	£	s.	d.	Cr.	£	s.	d.
To Audit Fee .. .. .	0	15	0	By Balance, 31/3/38 .. .. .	202	3	3
Stamp Duty .. .. .	1	0	0	Interest .. .. .	496	8	7
Administration Exs. .. .. .	2	0	0				
Carter Observatory Bd. 694 16 10							
	<u>£698</u>	<u>11</u>	<u>10</u>		<u>£698</u>	<u>11</u>	<u>10</u>

*Hector Memorial Fund.*

Dr.	£	s.	d.	Cr.	£	s.	d.
To Audit Fee .. .. .	0	5	0	By Balance, 31/3/38 .. .. .	130	3	0
Altering Medals .. .. .	40	18	6	Interest .. .. .	53	3	6
Duty on Medals .. .. .	4	3	4				
Exchange .. .. .	10	4	6				
Engraving Medals .. .. .	0	15	0				
Administration Exs. .. .. .	1	0	0				
Balance .. .. .	126	0	2				
	<u>£183</u>	<u>6</u>	<u>6</u>		<u>£183</u>	<u>6</u>	<u>6</u>
				By Balance .. .. .	£126	0	2

*Hutton Memorial Fund.*

<i>Dr.</i>			<i>Cr.</i>		
	£	s. d.		£	s. d.
To Audit Fee .. ..	0	5 0	By Balance, 31/3/38 ..	292	6 10
Grant (Dr. Turner) ..	9	0 0	Interest .. ..	62	19 1
Altering Medals ..	37	13 0			
Duty on Medals ..	2	1 8			
Exchange .. ..	9	8 1			
Engraving Medal ..	0	8 0			
Administration Exs. ..	1	0 0			
Balance .. ..	295	10 2			
	<u>£355</u>	<u>5 11</u>		<u>£355</u>	<u>5 11</u>
			By Balance .. ..	£295	10 2

*Hamilton Memorial Fund.*

<i>Dr.</i>			<i>Cr.</i>		
	£	s. d.		£	s. d.
To Audit Fee .. ..	0	2 6	By Balance, 31/3/38 ..	4	19 4
Prize (Dr. Hutton) ..	4	0 0	Interest .. ..	2	2 0
Half Interest to Capital	1	1 0			
Administration Exs. ..	0	2 6			
Balance .. ..	1	15 4			
	<u>£7</u>	<u>1 4</u>		<u>£7</u>	<u>1 4</u>
			By Balance .. ..	£1	15 4

*T. K. Sidey Summer-time Fund.*

<i>Dr.</i>			<i>Cr.</i>		
	£	s. d.		£	s. d.
To Audit Fee .. ..	0	5 0	By Balance, 31/3/38 ..	61	11 11
Altering Medals ..	34	12 6	Interest .. ..	22	11 3
Duty on Medals ..	2	1 8			
Exchange .. ..	8	13 0			
Tenth Income to Cap. ..	2	9 1			
Administration Exs. ..	1	2 0			
Balance .. ..	34	19 11			
	<u>£84</u>	<u>3 2</u>		<u>£84</u>	<u>3 2</u>
			By Balance .. ..	£34	19 11

*Carter Library Legacy.*

<i>Dr.</i>			<i>Cr.</i>		
	£	s. d.		£	s. d.
To Audit Fee .. ..	0	2 6	By Balance, 31/3/38 ..	41	7 11
Administration Exs. ..	0	5 0	Interest .. ..	9	5 1
Balance .. ..	50	5 6			
	<u>£50</u>	<u>13 0</u>		<u>£50</u>	<u>13 0</u>
			By Balance .. ..	£50	5 6

*Cockayne Memorial Fund.*

<i>Cr.</i>		
	£	s. d.
By Balance, 31/3/38 ..	260	9 5
Interest .. ..	6	16 10
Balance .. ..	<u>£267</u>	<u>6 3</u>



Mr. Aston stated that he had undertaken the convenership of the Committee while Dr. Oliver was absent from New Zealand, but he would now like to be relieved of it, and he nominated Dr. Oliver as convener. This was carried. It was resolved to add to the Committee, and Dr. H. H. Allan and Mr. L. E. Richdale were appointed.

*Annual Meeting Luncheon:* Professor Evans explained why it had been found impracticable to hold a luncheon this year.

Mr. Archey outlined the reasons which had prompted him to make the suggestion that a part of the Presidential Address should be given at an annual meeting luncheon to which guests would be invited.

After the members had expressed their views on the matter, it was resolved, on the motion of Mr. Stead, seconded by Mr. Archey: "That the Standing Committee be asked to endeavour to arrange a luncheon next year at a cost not exceeding 10s per member, and that it make up a list of guests to be invited."

*Monograph by Vavilov:* In reply to a question by Sir Thomas Easterfield, it was stated that the Monograph was not yet available.

*Soil Erosion:* As one of the members of the Soil Erosion Committee set up by the Government, Dr. Allan reported what had been done by the Committee, stating that the draft report of the Committee was ready for publication, and until it was published he could not disclose what measures were to be adopted.

#### HONORARY EDITOR'S REPORT.

During the year ending March 31, 1939, the four parts of Volume 68, comprising 649 pages and 71 plates, have been published. The material for the first part of Volume 69 has been sent to the Printer.

The following table shows the number of manuscripts handled:—

Manuscripts received in 1937, printed in Vol. 68, Part 1 ..		10
" " 1938, printed in Vol. 68 .. ..		22
" " 1938, rejected by referee .. ..		1
" " 1938, returned for revision .. ..		1
" " 1938, to be printed in Vol. 69 (1) ..		8
" " 1938, passed by referees, but held for later parts .. ..		9
" " 1939, to March 31 .. ..		2
Total .. ..		43

The average length of time between receiving the manuscripts and publishing is a trifle over six months. Last year's average has, therefore, been maintained, but it should be noted that the carry-over for Volume 69 is much larger than for Volume 68. Not only are the papers more numerous, but their length is greater.

Dr. H. J. Finlay has assisted greatly by reading proofs, and Dr. C. O. Hutton has helped in this and many other ways. For two months, during the writer's absence from Wellington, he carried on the duties of Editor.

J. MARWICK,

Honorary Editor.

The President, in moving the adoption of the Honorary Editor's report, stated that the Society was indebted to Dr. Marwick for the way in which he was carrying out his duties as Hon. Editor, and that Dr. Hutton and Dr. Finlay, who had ably helped him should also be thanked for their work. He considered that the annual meeting should recognise their services.

On the motion of Professor Segar, seconded by Dr. Focken, it was resolved that Dr. C. O. Hutton be appointed Associate Editor, and Dr. H. J. Finlay Assistant Hon. Editor.

Attention was drawn to the fact that as the *Proceedings* are not printed until the fourth Part, the Minutes of the Annual Meeting are very often not available until just before the next meeting.

On the motion of Dr. Focken, seconded by Dr. Hilgendorf, it was resolved that in future the *Proceedings* be printed in the first Part of each volume.

#### HON. LIBRARIAN'S REPORT.

Professor Evans,

The President of the Royal Society of New Zealand,  
Wellington.

Dear Sir,

I have been allowed to see the report of the Standing Committee, and find that it contains almost all that I could say about the Library. I have been able to do practically nothing, and the work that has been reported on is that of Miss Wood.

The plan for the establishment of a National Library seems to be in abeyance, and I find that there is no immediate prospect of its being otherwise. The Society will be informed when further steps are possible.

Faithfully yours,

H. B. KIRK,

Honorary Librarian.

On the motion of the President, the Hon. Librarian's report was adopted. He stated that the Society would have to face the expense of shifting to the new room provided in the new Biology Department at Victoria University College, and the space available would be much less than originally planned.

#### REPORTS OF RESEARCH GRANTEES.

*Mr. B. C. Aston* states that there is nothing further to report in connection with the research on *Puketea*.

*Dr. G. H. Cunningham*, who in 1929 was granted £25 for a mycological survey of the Tongariro National Park, reported on the 28th April that during Christmas and New Year ten days were spent at the Park in a camp on the slopes of Tongariro.

Fairly extensive collections were made in the forest on the northern slopes of Tongariro and tussock grassland near the Ketetahi springs. Unfortunately, most were lost subsequently, as during his absence from the camp specimens and drying papers were removed by a gale. The surviving collections contained no hitherto unrecorded species.

No expenses were incurred during the year.

*Professor B. J. Marples*, who in 1938 was granted £20 for a research on the food of the German Owl, reported on the 3rd April that the appeals for material were published and circulated to people likely to be interested. A reward of 1s was paid for every bird sent in. Ninety-seven owls have so far been received, but the numbers of castings and nests have been disappointing.

Investigation of these has been carried out systematically, and the following is the general result for the stomach contents of the first 50 birds only: 351 beetles, 239 caterpillars, 50 spiders, 36 orthoptera, 32 earwigs, 15 other insects, 4 birds, 4 mice, 4 lizards. Twenty-one of these owls contained the remains of earthworms.

Of the 37 owls examined for endoparasites, 20 were infected with a nematode worm, kindly identified by Dr. Bayliss, of the British Museum, as *Capillaria tenuissima*, a parasite which must have been brought to New Zealand with the owl. This is the only endoparasite which has been found.

It is proposed to carry on the investigation until June, 1940, thus covering two years.

Mr. Fisher has organised in Dunedin a scheme for the destruction of German Owls, with the object of preserving native birds. When approached with a view to obtaining the bodies of the owls killed by his collaborators, he replied that his funds could not be expended on paying the postage on these. The sum of £1 was accordingly sent to him for this purpose. Total expenditure to date, £6 2s 5d.

*Research Fund:* Sir Thomas Easterfield stated that it was regrettable that there were no funds for scientific research in the Society, and he thought the Government should be asked to restore part of the research vote.

The meeting considered it inadvisable to make the request at present.

#### TONGARIRO NATIONAL PARK BOARD.

In May, 1938, a meeting of the Park Board was held at the Chateau.

A question of trespass on the Board's property by timber-cutters on the south slope of Tongariro was dealt with by the Board, and the locality was visited by the members of the Board and steps were taken to prevent any further encroachment.

A small committee was appointed to report on the development of the species of heather which had been planted near the main highway.

Your representative brought up the question of the footpaths through the bush near the Chateau, and suggested that the more important of the plants should be properly labelled. A committee was appointed to deal with this, and also to obtain additional plants from other parts of the Park to place in the vicinity of the Chateau.

A number of plants near the paths have now been labelled, but extension of this is still required.

Mr. Blyth has planted a number of *Todea superba*, and species of *Ranunculus* and *Ourisia* are being planted.

P. MARSHALL,

Representative R.S.N.Z.

Dr. Marshall, representative on the Tongariro National Park Board, presented the above report, which was adopted.

## NATIONAL ART GALLERY AND DOMINION MUSEUM BOARD OF TRUSTEES.

The Board of Trustees met five times during the year ending 31st March, 1939, and all meetings were attended by your representatives.

The Conference between the Board of Trustees and representatives of Local Bodies referred to in last year's report has so far added £2378 per annum to the income of the Board, but the sum available is still too small.

The budgeting system introduced at the end of the previous year has proved of great use to the Management Committees of both Art Gallery and Museum.

The Director of the Museum, while on leave of absence, visited a large number (168) of museums in other countries, and the experience so gained should prove of value.

The work of the Educational Officer has been continued throughout the year. This work—which is carried on in an atmosphere less formal than that of a school—appears to be much appreciated.

In the National Art Gallery several successful exhibitions have been held, and an effort is now being made to secure a really representative collection of modern paintings for exhibition during the period of the Centennial Exhibition.

W. P. EVANS,

P. MARSHALL,

Representatives R.S.N.Z.

This report, presented by Professor Evans and Dr. Marshall, was adopted.

## ROYAL NEW ZEALAND INSTITUTE OF HORTICULTURE.

*School of Horticulture:* A resolution from the 1939 Conference was conveyed to the Prime Minister, asking for financial provision. The reply stated that the question was still under consideration.

The ninth National Conference of Horticulture was held at New Plymouth in February, 1939.

*Horticultural Education:* Twenty-two students sat in the November examinations of the Institute. The total number of diplomas and certificates granted since the inception of the statutory scheme is 363.

Advice was received through His Excellency the Governor-General that His Majesty the King had been graciously pleased to approve of the granting of permission to use the word "Royal" in the title of the Institute.

W. R. B. OLIVER,

Representative R.S.N.Z.

This report, presented by Dr. Oliver, was adopted.

## ARTHUR'S PASS NATIONAL PARK BOARD.

I beg to submit the following report concerning the work of the Arthur's Pass National Park Board for the year that has just ended.

Finance is always a matter for serious consideration by the Board, and appeals for assistance in this direction have been made to various local public bodies, and among them the Christchurch City Council has made a contribution of £50, and also the position has been greatly relieved by a Government grant of £350, which has allowed of the appointment of a permanent ranger-worker, the extension of developmental works in various parts of the area, and the maintenance of those already existing in a proper condition. The old track to

the Upper Waimakariri has been restored, and a new one made on the western slope of the range from the Taramakau River to Lake Kaurapataka. The Public Works Department has given serious consideration to the question of erosion threatened by the Bealey River, and to the straightening of the road through the settlement. Accommodation for trampers and others has also been increased by the erection of the Carroll Memorial Hut on Kelly's Range, Westland.

In order to reduce the risk of damage by fire, steps have been initiated in the direction of proclaiming the Park a "Fire District." Although valuable help has been given by volunteers in various emergencies in the past, it is considered that such a proclamation will secure more effective protection against fire for the forest covering of the area.

Substantial extensions to the alpine garden near the Railway Station have been carried out under the personal supervision of Mr. M. J. Barnett, Superintendent of Reserves to the Christchurch City Council, and it is hoped that in the near future a collection fully representative of the flora of the Park may be here assembled, and thus made readily available for examination by visitors from overseas and local botanists.

During the year the Park has been favoured by visits from two distinguished overseas botanists, Dr. Carl Skottsberg, of Gothenburg, Sweden, and Professor F. T. Brooks, of Cambridge, England. They both expressed their appreciation of the facilities offered by the Park for the study of New Zealand alpine flora.

R. SPEIGHT,

Representative R.S.N.Z.

The report of Professor Speight, representative on the Board, was adopted.

#### GREAT BARRIER REEF COMMITTEE.

A large number of islands and reefs have been declared National Parks.

Investigations on the corals of Moreton Bay are being undertaken under the direction of Dr. Dorothy Hill. Here the reefs come near the shore, the cause, apparently, being sand movements. Some of the reefs in Moreton Bay are composed only of dead coral.

The financial statement on 15th March, 1939, showed a balance of £1435 7s 10d, of which £800 was in bonds.

W. R. B. OLIVER,

Representative R.S.N.Z.

Dr. Oliver presented this report, which was adopted.

#### OBSERVATORIES COMMITTEE.

During the year two meetings have been held, but, unfortunately, through no fault of his, your representative has been unable to attend. The business transacted has been routine in the supervision of general observatory work.

The only important event to be recorded is the completion of the transfer of Government astronomical work to the Carter Observatory, to which the new Carter Astronomer, Mr. Geddes, has recently been appointed. No astronomical work will now be done by the Government. This has necessitated re-orientation of staff at Kelburn. Mr. Hayes remains on the staff as acting Seismologist, no permanent appointment having been made.

P. W. BURBIDGE,

Representative R.S.N.Z.

Professor P. W. Burbidge, one of the Society's representatives on the Observatories Committee, forwarded the above report, which was adopted.

## WARD ISLAND DOMAIN BOARD.

No meetings of the Ward Island Domain Board have taken place during the year, and no visits to the island have been made by the Board.

W. R. B. OLIVER,

Representative R.S.N.Z.

In presenting the report of the Ward Island Domain Board, which was adopted, Dr. Oliver stated that the Ward Island Domain Board was now defunct.

*National Parks:* Some discussion arose regarding the control of the various parks. It was considered that in view of the size of many of the parks the care provided could not be very adequate, though the representatives' reports showed that the parks were being cared for as far as possible.

As far as the Arthur's Pass Park was concerned, the risk of fire was minimised by the excessive rains.

Mr. Aston considered the Society should have representation on the Mount Egmont National Park Board.

Professor Hudson, in asking what was the function of a National Park, stated that a negative attitude seemed to be taken up, and little progress was being made in developing the parks along the lines adopted in other countries. He thought the Society should give a lead in the direction of advocating a policy of development in the conservation of national parks and the utilisation of such areas for the people of New Zealand. Mr. Callaghan supported Professor Hudson.

On the motion of Dr. Oliver, seconded by Dr. Allan, it was resolved to refer the matter to the Wild Life Committee to report to the Standing Committee.

Referring to the destruction of the forests by the red deer, Mr. Simpson moved, Dr. Allan seconded, and it was carried: "That the Society commend the Department of Internal Affairs for the measures taken to reduce the number of deer, and urge that its efforts be increased."

*Hutton Grant Application:* An application recommended by the Standing Committee was received from Mr. L. E. Richdale for a grant of £20 to cover expenses in connection with the ringing of birds, and on the motion of Mr. Hudson, seconded by Mr. Stead, was approved.

*Carter Library:* Professor Evans stated that the conditions laid down in the transfer of the Carter Library to the Turnbull Library were not being carried out, and moved that the matter be referred to the Standing Committee.—Carried.

*Certificate of Membership:* On the motion of Professor Evans, seconded by Mr. Archey, it was resolved: "That the Standing Committee be authorised to frame a suitable 'Certificate of Admission as a Member-Body' and to issue such a certificate under the common seal of the Society to each member-body now entitled to receive one, without waiting for any further application therefor."

*Member-Bodies' Reports:* On the motion of Professor Evans, seconded by Mr. Callaghan, it was resolved: "That the practice of printing in the Appendix to the *Transactions* accounts of the activities of the various member-bodies with brief extracts of the more important papers read before them but not forwarded for publication in full, be revived as from the date of this meeting; and that the Councils of member-bodies be asked to furnish such accounts in duly edited form."

*Election of Officers:* The following officers were elected:—President, Rev. Dr. J. E. Holloway; Vice-President, Professor W. P. Evans; Hon. Treasurer, Mr. M. A. Elliott; Hon. Librarian, Professor H. B. Kirk; Hon. Editor, Dr. J. Marwick; Hon. Associate Editor, Dr. C. O. Hutton; Hon. Assistant Editor, Dr. H. J. Finlay; Co-opted Member, Dr. P. Marshall; Managers of Trust Funds, Mr. M. A. Elliott and Mr. B. C. Aston; Representative N.Z. Institute of Horticulture, Dr. W. R. B. Oliver; Representative Great Barrier Reef Committee, Dr. W. R. B. Oliver; Representatives Observatories Committee, Professor P. W. Burbidge and Professor D. C. H. Florance.

*Election of Committees:*

Hector Award Committee: Professor Evans (convener), Dr. C. Coleridge Farr and Dr. G. E. Weatherburn.

Hutton Award Committee: Dr. Marshall (convener), Dr. Benham, Dr. Holloway, Mr. Hudson, and Dr. Cunningham.

Finance Committee: Mr. M. A. Elliott, Mr. B. C. Aston and Dr. Marsden.

Library Committee: Professor Kirk, Professor Cotton, Dr. Kidson and Dr. Oliver.

Fellowship Selection Committee: Mr. Aston (convener), Dr. J. Henderson, Professor Evans, Mr. Archey and Professor Segar.

Wild Life Control Committee: Dr. Oliver (Convener), Dr. H. H. Allan, Mr. Aston, Mr. Archey, Mr. Stead, Mr. R. A. Falla, Mr. L. E. Richdale, and the President.

*Votes of Thanks:* A very hearty vote of thanks was accorded to the retiring President, Professor W. P. Evans, for his work during the last two years.

Votes of thanks were also accorded to Victoria University College for the use of its rooms, to the Press, and to the Secretary (Miss M. Wood).

*Annual Meeting, 1940:* The date of the Annual Meeting, to be held in Wellington in 1940, was left to the Standing Committee to arrange.

## PRESIDENTIAL ADDRESS

[Delivered at the Annual Meeting at Wellington on May 23rd, 1939,  
by Emeritus-Professor W. P. Evans, M.A., Ph.D., F.R.S.N.Z.,  
F.I.C.N.Z.]

GENTLEMEN,—

A second year of office has given me the privilege, but, at the same time the responsibility, of delivering a second presidential address. At your request that address was divided into two independent sections, the second of which was to be delivered after an informal luncheon had given you strength to bear it. Unfortunately, it was found impracticable to carry out this plan fully; and so I must ask you to be patient, and listen to the whole address now.

My first duty is to welcome two new members of the Council. Dr. C. M. Focken and Mr. G. Simpson take their seats as representatives of the Society's Otago Branch; the former representatives, Professor Park and Dr. Turner, having resigned. Of Dr. Turner's services I spoke at our last meeting; of Professor Park's long continued and highly valued connection with the Council formal mention will be made later.

During the year just passed we have lost one of our Honorary Members, J. W. Mellor, C.B.E., D.Sc., F.R.S. (elected 1919; died 1938); and one of our Fellows, J. S. Maclaurin, D.Sc., F.C.S. (elected 1926; died 1939).

**Joseph William Mellor** was born at Huddersfield, England, on July 9th, 1869, and came to New Zealand when he was about ten years old.

He was a boy who was determined to work his way upwards, and, though engaged all day long as a clicker, attended evening classes first at the Dunedin Technical School, and later at the University of Otago. At the University his flair for chemistry soon became evident, and he went steadily ahead to his Master's degree, and a lectureship at Lincoln Agricultural College.

In 1889 he was nominated as New Zealand's 1851 Exhibition Scholar, and, on his nomination being accepted by the Commissioners, returned to England in order to make the study of chemistry his life-work. The potteries of Staffordshire attracted him strongly, and he devoted much of his time to the solution of their various problems.

For some years he was Principal of the pottery school of the North Staffordshire Technical College, and also sometime Director of the British Refractories Research Association. In addition he acted for many years as Secretary of the Ceramic Society.

Probably his best-known work is the *Comprehensive Treatise on Inorganic and Theoretical Chemistry*, a huge sixteen-volume book of reference, the compilation of which occupied most of his later years. His best work, from the scientific standpoint, was that connected with refractories, and the manufacture of special steels; work which assumed great importance during the critical years following 1914.

He was elected a Fellow of the Royal Society of London in 1927. He died at his residence at Putney on May 24th, 1938, just three days before our last annual meeting.

**James Scott MacLaurin** came out from England with his parents when he was still a boy, and, after attending the Auckland Grammar School, graduated from Auckland University College with first-class honours in chemistry. The excellence of his chemical work at the University gained for him the Fellowship of the Chemical Society of London. In 1894 he was elected to an 1851 Exhibition Scholarship, but, for family reasons, decided not to accept it.

After some years of private practice as an analyst, he joined the Mines Department, and found that his great ability as an analyst enabled him to answer satisfactorily the many questions put to him by the various Government departments that sought his aid. Later he became Dominion Analyst and continued to superintend the growing staff of the Dominion Laboratory until the end of 1930, when he retired.

The arduous duties of his several positions left him but scant time for the research work for which he was so eminently fitted, but some of his official reports show as much original chemical work as if they had been studies in purely academic science. His thesis for the degree of D.Sc. has become a classic in the literature of metallurgy, and his discovery of the important part played by oxygen in the solutions used for recovering gold led to vastly increased yields of that metal.

He died at Wellington on the 19th January, 1939.

On your behalf I extend very hearty congratulations to the Society's Vice-President, Dr. P. Marshall, upon his being unanimously selected by the General Council of the Australian and New Zealand Association for the Advancement of Science as President-elect of the Association.

I also congratulate another member of the Council, Dr. W. R. B. Oliver, upon his election as a British Empire Member of the British Ornithologists' Union.

The Standing Committee's report has recalled to your minds the main activities of the Society during the past year, and has probably suggested a few points for discussion.

On April 26th of this year (and therefore too late for inclusion in the report), the Wellington Philosophical Society, one of the oldest of our member-bodies, decided to change its name to Royal Society of New Zealand (Wellington Branch).

**Carter Bequest.**—It will be remembered that, at the annual meeting held on May 27th, 1937, the Council after duly considering the "Report of the Technical Sub-committee set up to Consider and Report on a Suitable Scheme for Equipping the Carter Observatory; and Probable Cost of Same," instructed the Standing Committee to transfer the accumulated funds belonging to the Carter Trust to the proposed Statutory Board of Trustees as soon as it was satisfied that the sum necessary for the service and upkeep of the proposed Carter Observatory, viz., £1000 per annum, was definitely assured; and expressed the opinion that the sums to be contributed annually by the Government, and the Wellington City Council, respectively, ought not to be subject to annual vote, but should be made statutory under the Empowering Act.

Subsequently the Carter Observatory Act of September 14th, 1938, completely discharged "the trusts declared in the will of the said Charles Rooking Carter" and vested "the moneys comprised in the . . . bequest of the said Charles Rooking Carter, together with the accumulated income thereof, the securities in which any such moneys are invested, and all rights of the Royal Society of New Zealand in relation thereto" in the Carter Observatory Board "for the exercise of the Board's functions."

The Standing Committee therefore instructed the Managers of the Society's trust accounts to take whatever steps were necessary to transfer all moneys and securities belonging to the Carter Bequest to the Carter Observatory Board as soon as that Board was duly constituted and the names of its members gazetted.

The constitution of the said Board was duly announced on January 19th, 1939, and all the moneys previously held in trust by the Royal Society of New Zealand were then transferred to the officers of the Board, and the seal of the Royal Society was affixed to the transfer documents.

The Council of the Royal Society of New Zealand, as collective trustee for the Carter Bequest from 1896 to 1939, has at times been subjected to much adverse criticism for its determination that the moneys involved should not be used until there was a definite prospect of their being used to advantage; though most of that criticism appears to have been due to a want of appreciation of the facts. It is, perhaps, as well to place on record in our "Transactions" that, after the relevant facts had been put before the Conference called to consider the best use to be made of the accumulated funds, it was unanimously resolved that "a vote of appreciation and thanks be made to the Royal Society for the way in which they have looked after the funds."

The Royal Society of New Zealand has now no liability whatever in the Carter Bequest; and it only remains for us to express the wish that the Observatory soon to be erected and equipped may, under the guidance of its young and able Director, prove of value not only to the Dominion of New Zealand, but also to the whole world of science.

**Canberra Meeting.**—The biennial meeting of the A. and N.Z.A.A.S., held this year at Canberra, was attended by over twelve hundred members and associate-members. The surroundings of the Commonwealth Capital City, though not at their best owing to the long drought and the abnormally high temperatures prevailing, formed a picturesque, if somewhat inconvenient, setting for the meeting, which lasted from the 11th to the 18th of January.

Many of the papers read at the meeting were of more than usual merit, and one or two of the symposia led to conclusions which should prove of value in connexion with future work. A full report of the meeting will be published in due course.

Two features of interest to this Society were the success attending the geology section under the guidance of one of the Society's representatives, Professor R. Speight; and the selection, already referred to, of another representative, Dr. P. Marshall, as President-elect.

The representatives of the Society at the meeting were greatly indebted to some of the residents of Canberra, and the staff of the Stromlo Observatory, for their kindness in providing cars when the general transport arrangements failed.

I come now to the second section of my address; a section for which I have chosen a semi-historical subject—**Two Royal Societies**: those of London, and New Zealand; the former (christened "Royal" in 1662), not only the oldest but also by far the most renowned in the British Empire; the latter (christened in 1933), the youngest, and perhaps the least known of that small group to which the ancient title "Royal Society" has been granted.

I propose to speak to you briefly, and perhaps for that reason baldly, of their origin, and their aims.

Their origins, naturally enough, were similar. It is characteristic of man that so soon as he has mounted a hobby-horse he should desire to ride with others similarly mounted, so that he may bore them with his views regarding the particular hobby they are riding. In this way one or two Londoners interested in the experimental science of their day gathered to themselves others with like interests, and by 1645, "divers worthy persons inquisitive into natural philosophy, and other parts of human learning; and particularly of what hath been called the *New Philosophy* or *Experimental Philosophy*" held weekly meetings at one or another convenient house or tavern.\* They certainly emptied their tankards of ale, but they were very much in earnest, and it is fairly evident that "The Invisible College" of Boyle's letters is nothing but this ancient company of philosophers.

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\* "These meetings we held sometimes at Dr. Goddard's lodgings in Wood Street (or some convenient place near), on occasion of his keeping an operator for grinding glasses for telescopes and microscopes; sometimes at a convenient place (The Bull Head) in Cheapside, and at Gresham College . . . and after the lecture ended, repaired . . . to some other place not far distant." (Wallis's "A Defence of the Royal Society," 1678.)

Writing about thirty-five years later, one of this old Company states: "Our business was (precluding matters of theology and state affairs) to discourse and consider of *Philosophical Enquiries*, and such as related thereunto; as *Physick, Anatomy, Geometry, Astronomy, Navigation, Staticks, Magneticks, Chymicks, Mechanicks*, and natural *Experiments*; with the state of these studies, as then cultivated at home and abroad."

Some of these philosophers left for Oxford and formed a second group in close connexion with the first, but gradually the activities of both became centred in London, with Gresham College as their principal place of meeting.

The secretaries of the company kept its journals, and in the first journal-book we find the entry: "Memorandum that November 28, 1660, These persons following, according to the usuall custom of most of them, mett together at Gresham College to heare Mr Wren's lecture, viz., The Lord Brounker, Mr. Boyle, Mr. Bruce, Sir Robert Moray, Sir Paul Neile, Dr. Wilkins, Dr. Goddard, Dr. Petty, Mr. Ball, Mr. Rooke, Mr. Wren, Mr. Hill. And after the lecture was ended, they did, according to the usuall manner, withdraw for mutuall converse, Where amongst other matters that were discoursed of, something was offered about a designe of founding a Colledge for the promoting of Physico-Mathematicall Experimentall Learning. And because they had these frequent occasions of meeting with one another, it was proposed that some course might be thought of, to improve this meeting to a more regular way of debating things, and according to the manner in other countryes, where there were voluntary associations of men in academies, for the advancement of various parts of learning, so that they might doe something answerable here for the promoting of experimentall philosophy. In order to which, it was agreed that this Company would continue their weekly meetings on Wednesday, at 3 of the clock in the terme time, at Mr. Rooke's chamber at Gresham Colledge, in the vacation, at Mr. Ball's chamber in the Temple. And towards the defraying of occasionall expenses, every one should, at his first admission, pay downe ten shillings, and besides engage to pay one shilling weekly, whether present or absent, whilst he shall please to keep his relation to this Company."

At this meeting also a chairman was elected (Dr. Wilkins), and a list of forty-one persons "judged likely and fit to join the designe" drawn up.

The new Society grew apace,\* for, next week, "Sir Robert Moray brought in word from the court, that the King had been acquainted with the designe of this Meeting, and he did well

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\* The Society was now properly constituted, and among its rules we find: "The standing Officers of the Society to be three, that is to say, a President or Director, a Treasurer, and a Register. The President to be chosen monthly," and "That at every meeting, three or four of the Society be desired that they would please to be reporters for that meeting, to sitt at table with the Register and take notes of all that shall be materially offered to the Society and debated in it, who together may form a report against the next meeting to be filed by the Register."

There be "likewise two servants belonging to this Society, an Amanuensis, and an Operator." The salary of the Amanuensis was "40 l. per annum," that of the Operator "four pounds by the yeare."

approve of it, and would be ready to give encouragement to it," and its form of obligation was duly signed by all those present at the previous meeting, and by seventy-three others.

Such rapid growth, however, was considered unhealthy, and on December 12th of the same year it was resolved "That the stated number of this Society be five and fifty," and to accept "any person of the degree of Baron or above," "Fellowes of the Colledge of Physitians," and "the Publick Professors of Mathematicks, Physick, and Naturall Philosophy, of both Universitys, as Supernumerarys . . . . they submitting to the Lawes of the Society, both as to the pay at their admission, and the weekly allowance; as likewise the particular works or tasks that may be allotted to them."

In October, 1661, the King himself offered to be entered as a member, and in 1662 the Society was incorporated under the title: "The Royal Society for the improving of Natural Knowledge."

The Society's first charter† passed the Great Seal on July 15th, 1662. This is therefore the date of the beginning of the Royal Society of London. The charter was read before the Society on August 13th, and on August 29th, President, Council, and Fellows, went to Whitehall and thanked his Majesty. A second charter, confirming the first, but granting further desired privileges, passed the Great Seal on April 22nd, 1663; and a third, which is unimportant, on April 8th, 1669. It is the second charter which secures the Society its privileges, and by which it is still governed.

The Council met for the first time on May 13th, 1663, when it was decided that debates regarding admission to the Society should be secret, and that Fellows should pay one shilling a week to defray expenses.

In the early years of its history the two most important functions of the Society were undoubtedly correspondence with foreign philosophers (correspondence which furnished the beginnings of the "Philosophical Transactions"‡), and the performance of experiments before the members. In the warrant of 1663 ordering the

† This first charter headed: CHARTA PRIMA. Praesidi, Concilio, et Sodalibus REGALIS SOCIETATIS Londini, a Rege CAROLO SECONDO concessa, A.D. MDCLXII., begins with the words—CAROLUS SECUNDUS, Dei gratia Angliae, Scotiae, Franciae et Hiberniae Rex . . . . and ends Teste me Ipso, apud Westmonasterium, quinto decimo die Julii, anno regni nostri decimo quarto. The charter, which is on four skins of vellum, was drawn up by Sir Robert Sawyer (then Attorney-General), and is considered remarkable for its clearness.

‡ The printing of these "Philosophical Transactions" began in 1665, the first number bearing the date: March 6, 1664-65. Until 1753, however, the folio sheets, and parts, issued were not printed at the cost of the Society, nor was the Society involved in any risk concerning them. Though licensed by the President, "the printing of them was always, from time to time, the single act of the respective Secretaries," and, at the outset, the printing was a speculation on the part of Henry Oldenburg. This system of licensing was continued through 46 volumes (496 numbers), but with volume 47 (pub. 1753) the publication was placed directly in the hands of the President and Council, and a Committee of Papers established.

From time to time the Council gave the imprimatur of the Society to certain books, but again was not responsible for the cost of printing. Among these licensed books were Hooke's *Micrographia*; Papin's *A New Digester*; Evelyn's *Sylva*; and Newton's *Principia*.

silver mace§ which Charles II presented to the Society, it is described as: "The Royal Society for the improving of Natural Knowledge by experiments"; and its charter gave it power to appoint two "Curators of experiments."

The importance attached to experiments carried out at the meetings is shown by the Society early availing itself of this power and appointing, in 1664, as one of the Curators, Robert Hooke,¶ who had been assistant to the Hon. Robert Boyle, admitting him at the same time as a Fellow of the Society. He was elected "for perpetuity, with a salary of £30 a year, *pro-tempore*," and given apartments. In 1684, Denis Papin was appointed Joint-Curator with Hooke. Some of the experiments were instituted at the instigation of Charles II; and very often, we are told, the Society prepared experiments hoping, but in vain, that the King would do them the honour to witness them.

Although the Royal Society was now a body corporate under royal charter, it continued to conduct its meetings much as they had been conducted when its members met as a private company, and a good idea of the character of these early meetings may be gained from the following extracts from the Journal-Book minutes of the fourth meeting after that at which the charter had been read.

September 10th, 1662.

"Mersennus, his account of the tenacity of cylindrical bodies was read by Mr. Croone, to whom the prosecution of that matter by consulting Galilæo, was referred when the translation of that Italian treatise wherein he handleth of this subject shall bee printed."

"The reading of the french manuscript brought in by Sir Robert Moray about taking heights and distances by catoptricks was deferred till the description of the instrument should come."

"Dr Goddard made an experiment concerning the force that presseth the aire into lesse dimensions; and it was found that twelve ounces did contract 1/24 part of Aire. The quantity of Air is wanting."

"Dr Charleton read an Essay of his, concerning the velocity of sounds, direct and reflexe, and was desired to prosecute this matter; and to bring his discourse again next day to be enter'd."

"Mr. Evelyn's experiment was brought in of Animal engrafting, and in particular of making a Cock spur grow on a Cock's head."

"Dr Goddard made the experiment to show how much aire a man's lungs may hold, by sucking up water into a separating glasse after the lungs had been well emptied of aire. Several persons of the Society trying it, some sucked up in one suction about three pintes of water, one six, another eight pintes and three quarters,

§ At a meeting held on December 14, 1663, it was—"Ordered, that the Secretary bring in a list of the Names of all the Benefactors to the Society, together with their Donations, and the time when they presented them." It was also—"Ordered that the Benefactors be registered in loose vellum sheets." Unfortunately these early "vellum sheets" are no longer in existence, but in the lists prepared from the Index to the MS Council Minutes we find: "KING CHARLES II, 1663. Presented the Society with a mace of silver, richly gilt, weighing 190oz averdupois."

¶ The dates of Hooke's appointment as Curator, and of his election as a Fellow, are doubtful. Those given above are taken from p. 17 of *The Record of the Royal Society of London* (Harrison and Sons, 1897), but an article (unsigned) on Hooke in the *Encyc. Brit.* says that he was appointed Curator on November 12, 1662, and elected a Fellow in 1663. Curiously enough *The Record* itself confirms this latter statement, for, on p. 9, it gives: "Robert Hooke, M.A.—afterwards LL.D. Born July 18, 1635. Died March 3, 1702," in a list of those declared "Members of the Society" at a meeting held on May 20, 1663. As *The Record* appears to have made bad use of the records in this case, it may well be wrong in the other. Hooke retained the office of Curator of Experiments until his death; Papin until his appointment, in 1687, to the chair of mathematics in the University of Marburg.

etc. Here was observed the variety of whistles or tones, which ye water made at the severall hights, in falling out of the glasse again."

"It was discoursed whether there bee any such thing as sexes in trees and other plants; . . . ."

"Mr Boyle shew'd a Puppey in a certain liquour, wherein it had been preserved during all the hott months of the Summer, though in a broken and unsealed glasse."

At times, these philosophers of a bygone age may seem to have been like children at their games, but our own age is surely much the richer because they played.

The Society now grew steadily—the limit of fifty-five had already proved too small—and its members became keenly interested in the formation of a museum (the collections in this museum were handed over to the British Museum in 1781), and in the establishment of a library. This library, at first almost entirely literary in character, was gradually converted—by sale and exchange—into a scientific one.

As is so often the case, increasing numbers bred discontent; and in 1788, after very heated discussions had for some time been common, some of those less mathematically inclined finding it increasingly difficult under the policy of the then President (Sir Joseph Banks) to obtain admission for their friends, seceded, and formed a new society—The Linnean Society—the first separate scientific society to be formed under royal charter.

Since that time many other societies have been founded in Great Britain for the promotion of special branches of science; but the Royal Society of London has always easily maintained its premier position, and now consists of over four hundred and fifty British Fellows, some forty-eight Foreign Members, and a few Royal Fellows; it is by far the most powerful society of its class in the world; possesses much valuable property; has a right princely income, and is largely responsible for the proper application of many of the grants made by the British Government for scientific research.

I turn now for a while to the young Royal Society of New Zealand. In the early years of the Colony's history, small groups, rapidly developing into societies, were formed to discuss the many fascinating problems (geological, botanical, zoological, engineering) which the very newness of the land brought so prominently forward. The first of these was "The New Zealand Society," founded at Wellington in 1851, but, under various names, they were soon scattered from the north to the south of the Colony. Each of these societies held regular meetings, each began to collect a library, some started museums, and the members of each (elected in most cases by ballot) were required to abide by certain rules, and to pay a small annual subscription.

New Zealand's drawn-out length demanded such scattered groups, but, at the same time, the necessity for some central body soon became felt, and on October 10th, 1867, an Act of Parliament established a body corporate to be called "The New Zealand Institute."

This Institute was to "comprise a public museum and laboratory and a public library" and was also "by means of lectures classes and otherwise to promote the general study and cultivation of the various branches and departments of art science literature and philosophy." It was also so closely bound up with "carrying out the geological survey of the Colony" that is very difficult to determine whether the surveying or the other activities mentioned in the Act ranked first.

The Institute was placed under the control of a Board of Governors consisting of the Colonial Secretary, the Superintendent of the Province of Wellington, and six others nominated by the Governor.

The Institute Act gave to a number of the existing small scientific bodies the right to become integral parts of the Institute and to take what little share they could get in its management. Within a few years all of them had exercised this right, and the Institute had, in theory, become a federation of autonomous societies.

The Institute was "opened by a *conversazione* at the museum on the evening of April 4th, 1868, when many members of various local societies for the promotion of Art and Science assembled to listen to the inaugural address of his Excellency the Governor (Sir George Bowen, G.C.M.G.).

The first set of rules and statutes was gazetted on March 9th, 1868, and James Hector, M.D., F.R.S. (afterwards Sir J.) nominated Manager.

To the layman it seems quite clear that the Institute was for some time the actual owner of the museum, the library, and the ground on which they stood, and was thus comparatively well-to-do, but its worldly prosperity was not destined to last for long, as the separation of the museum and the geological survey took from it all but a portion of the library, the small annual grant, and the right to consider the old museum its head-quarters until that might be deemed inconvenient.

The Institute's somewhat unsatisfactory constitution, coupled with the fact that the three offices of Director of the Geological Survey, Curator of the Museum, and Manager of the Institute, were all held by one man, led, in time, to what might almost be called a dictatorship, and, in consequence, to grave discontent. A major crisis was approaching rapidly when, by an Act of November 18th, 1903, the Institute was reconstituted, and its eight constituent societies on whose strength the very life of the Institute depended, given much more effective representation upon the Board of Governors, and a voice in the election of the President.

As a scientific body, however, the Institute remained essentially unchanged, continuing a quiet but increasingly active life until, in 1933, his late Majesty King George V was graciously pleased to

grant the title "Royal Society," so that "this country might follow the precedents which had been established in other parts of his Dominions."

The Royal Society Act of December 6th, 1933, makes all the active branches of the old New Zealand Institute "member-bodies" (a horrid instance of word-coining) of the Royal Society of New Zealand, which now has a membership of nearly twelve hundred, though less than seven hundred of these contribute to the cost of publishing its *Transactions*.

May I recapitulate?

Each of the societies we have been considering started as a small company of men interested in science.

Each was active for some years before it was christened "Royal"; the London society having reached its late 'teens, while that of New Zealand had actually attained the fairly mature age of sixty-six.

Each demanded a subscription from its members, and the amount so subscribed was used chiefly in publishing *Transactions* in which were recorded the results of scientific research.

Each (by ballot following nomination) elected a number of Fellows, but, while for many years past the Royal Society of London (if we except its four Royal Fellows) has consisted entirely of Fellows and Foreign Members elected for the value of their scientific work, the membership of the Royal Society of New Zealand is open to all who are willing to behave themselves and pay the small sum of twenty-one shillings each year; and the number of its Fellows is at present limited to forty. These New Zealand Fellows form the nucleus of what will no doubt ultimately be a considerably larger body, and enjoy their position without being called upon for any extra subscription, while their more illustrious brothers of London are required to pay an admission fee of ten pounds, and annually, in advance, the sum of five pounds.

The Royal Society of London is a limited republic whose citizens are all numbered amongst the aristocrats of science, and is governed by an elected President and Council.

The Royal Society of New Zealand is a federation of several small republics each with its own President and Council, though subject in matters of general policy, and paying a small portion (considerably less than one quarter) of its revenue to the general Council of the federation.

The Royal Society of London, born under royalty in a country which was already both old and rich, is extremely wealthy, and is entirely free from political control.

The Royal Society of New Zealand, started in a new and struggling land, is very poor, and—unfortunately—still depends for much of its publishing work upon an annual Government grant, which has been as variable as such things generally are.

What are the aims of these two societies, so different in age and dignity, but yet so closely related?

The full title of the older: "The Royal Society of London for promoting Natural Knowledge," and the Act of 1933 which establishes "The Royal Society of New Zealand" as "a Body for the Promotion of Science," give a partial answer. Each is entrusted with the promotion of science.

Unfortunately, the very word science is unscientific in as much as it is ill-defined, but for most practical purposes science now means biology, chemistry, geology, physics (including astronomy), and mathematics, though mathematics may be looked upon as "an intellectual box-of-tools" placed at the disposal of any science that is able to use it. There is indeed a growing danger that in the near future an attempt may be made to determine the rank of a science almost entirely by the extent to which it successfully—and legitimately—uses its mathematical tools.

This restriction of the term science is, of course, quite arbitrary, and to some extent misleading, for it must be remembered that there are few, if any, branches of learning which cannot be made more or less scientific, and "scarcely any mental or moral faculty which science cannot develop and discipline."

Science in the stricter sense rests on, consists of, those principles of knowledge that are founded on experiment and observation, and are capable of being reduced to laws (again unscientific, for they are simply generalisations) of a fairly definite character. Experiment and observation to be scientific must, however, be exact; guesses are certainly "a pleasant stimulus to the imagination" and sometimes spurs to industry, but they are not science. The scientist approaches all problems with one purpose—by means of observation, measurement, and comparison, to discover the truth. It is taken for granted that his evidence has been carefully weighed, and his conclusions based on the significance of the ascertained facts; not on any preconceived notions or personal predilections. He may, of course, have predetermined ideas of what the facts are, and is certainly entitled to rejoice when his experiments confirm those ideas; but, if he twists the ascertained facts to fit his theories, he is no scientist; though he may be a charlatan, or a fool.

How far have these Societies been successful in their quest? Have they discovered any truths? That question no man can answer definitely: the accepted truth of one generation may well become an untruth for the next: indeed, one good reason for recording our present views is to give posterity the pleasure of finding out how

wrong we were. Nevertheless, it may certainly be said that the members of both Royal Societies have honestly tried to get nearer the truth; and that the story of their endeavours, as related in the long series of *Transactions* published by them, is generally looked upon as a reliable guide towards further advances.

Voltaire's fine tribute to the Royal Society of London, written in 1743, when that society was only eighty years old, is even more merited to-day. It has indeed been "The Free Society of London," and has "worked for the honour of working." It has looked for the truth, and has been allowed to approach it.

Of our own Royal Society it would not be fitting that I should say much; but I do feel justified in expressing the opinion that, considering the conditions under which it was born and has grown up, it has not shown itself altogether unworthy of the famous London Society of which it is the great- (repeated seven times) grand-child.

The present day, for us, is still too close to the past, and we must leave it to those coming long after us to decide whether the presence of a "Royal Society" in our land was, speaking generally, a liability or an asset. I sincerely hope, and really believe, that the verdict will be "an asset."

One thing, however, is certain—there is still room for such societies, for "one of the fascinations of the study of Nature is that there are so many puzzles and so few really satisfactory answers." To many of Nature's questions we can as yet find no answers at all, but our failure does not erase the questions, and science will continue to search for the answers; nor shall that search prove fruitless if it is made in the right spirit, not boastingly, not relying upon past successes; but earnestly, and humbly realizing that, in so far as it is part of the search for eternal truth, in so far it is consecrate.

In conclusion, I should like to thank the members of the Standing Committee for their support during the year. I must also thank the Society's Secretary for the prompt and efficient manner in which she has carried out not only her own work, but, in addition, much that might legitimately have been left to me.



TRANSACTIONS



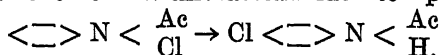


## The Temperature Coefficient of the Decomposition of *N*-chloracetanilide.

By R. A. ROBINSON and G. M. SMITH, Auckland University College.

[Read before Auckland Institute, September 21, 1938; received by the Editor, October 13, 1938; issued separately, June, 1939.]

THE rearrangement of *N*-chloracetanilide to *p*-chloracetanilide,



in hydrochloric acid solution has often been quoted in support of the "activity rate" hypothesis of chemical kinetics, according to which the "active masses" of the Guldberg-Waage Law are to be identified with the thermodynamic activities of the reacting species rather than the ionic concentrations. In the case of a balanced reaction the thermodynamic Law of Mass Action follows directly. Because of our ignorance of the value of the activity of a single ion, however (see Taylor, 1927) the hypothesis cannot be tested directly by means of reactions between a neutral molecule and one ion. The more favourable case of a reaction between a neutral molecule and two oppositely charged ions is rarer and for this reason the rearrangement of *N*-chloracetanilide assumes considerable importance in the modern theory of solutions. The reaction has been studied by Rivett (1913), Harned (1918), Akerlöf (1922), and Harned and Seltz (1922), the data of the last mentioned conforming with the equation:

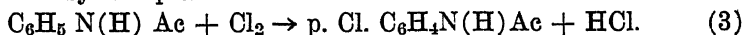
$$-d[A]/dt = k [A] \gamma_{\text{H}} \gamma_{\text{Cl}} C_{\text{H}} C_{\text{Cl}} \quad (1)$$

[A] being the concentration of *N*-chloracetanilide,  $\sqrt{\gamma_{\text{H}} \gamma_{\text{Cl}}}$  the mean activity coefficient of hydrochloric acid and  $C_{\text{H}}, C_{\text{Cl}}$  the ion concentrations. Two disconcerting results of their investigation were the dependence of the temperature coefficient of the reaction rate on the temperature and the failure of the simple equation (1) for reactions proceeding in the presence of neutral salts. The latter difficulty has been emphasised by Belton (1930) and also by Dawson and Millet (1932), who discard the activity rate hypothesis in favour of catalysis by undissociated hydrochloric acid molecules.

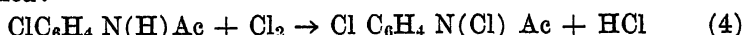
The work of Soper and Pryde (1927), however, has reopened the whole question. They have shown that the rearrangement proceeds by a slow reaction:



followed by a rapid chlorination:



The second reaction, however, does not always occur, as the chlorine may be taken up by a molecule of *p*-chloracetanilide previously formed:



the chlorine attached to the nitrogen being reactive to potassium iodide in the same way as the chlorine of the *N*-chloranilide whose rate of decomposition is followed by addition of potassium iodide

and titration of the liberated iodine. In other words, the side-reaction (4) lowers the observed rate of rearrangement. This reaction can be avoided by the addition of an excess of an easily chlorinated substance such as phenol, p-cresol or acetanilide.

In addition, a simultaneous hydrolysis occurs, catalysed by hydrogen ions:

$C_6H_5N(Cl)Ac + H^+ + H_2O \rightarrow C_6H_5N(H)Ac + HOCl + H^+$  (5)  
and this effect has to be measured by means of experiments in other acid solutions. Soper and Pryde also used the activity of the anilide rather than the concentration, the activity coefficient being determined from solubility measurements. Their results favour the activity rate hypothesis.

The following work was commenced as a study of the kinetics of a termolecular reaction in solution and particularly with the hope that the refinements introduced by Soper and Pryde would account for the variable temperature coefficient and for the failure of the activity rate hypothesis in the presence of neutral salts. Our expectations were realised with regard to the former but not with regard to the latter.

#### EXPERIMENTAL.

N-chloracetanilide was prepared by the method of Barnes and Porter (1930) and its rate of decomposition followed in 0.01 *M* solution by the addition of potassium iodide to aliquot samples and titration of the liberated iodine with thiosulphate. The first series of measurements were made in hydrochloric acid solution ranging from 0.1 to 1.0 *M*, both with and without the addition of 0.03 *M* phenol. In Table I  $k'$  is the unimolecular velocity constant in the absence of phenol; the figures agree satisfactorily with those of Harned and Seltz.  $k_1$  is the constant in presence of phenol, the data again agreeing with those of Soper and Pryde;  $k_2$  is the velocity-constant found in nitric acid solution of corresponding strength, the figures in brackets being interpolated;  $k$  is the difference ( $k_1 - k_2$ ). Solubility measurements recorded at the foot of the table give the activity coefficient of the anilide,  $\gamma_{NCl}$ . Finally  $K$  is the termolecular velocity constant  $k/(\gamma_{NCl}\gamma_{HCl}^2C_HC_{Cl})$ ,  $\gamma_{HCl}$  being taken from the data of Randall and Young (1928). The constancy of the figures in the last column supports the activity rate hypothesis for this medium. In this paper velocity constants will be expressed with minutes and mols. per litre as units. This will facilitate comparison with other data.

TABLE I.  
REACTION RATES IN HYDROCHLORIC ACID SOLUTION AT 25°.

<i>M</i> -HCl	$k' \times 10^3$	$k_1 \times 10^3$	$k_2 \times 10^3$	$\gamma_{NCl}$	<i>K</i>
0.1	0.48	0.51	0.0335	0.991	.0760
0.2	1.71	1.89	(0.051)	.982	.0798
0.3	3.77	4.10	0.095	.973	.0795
0.4	6.56	7.15	(0.12)	.964	.0800
0.5	10.4	11.2	0.15	.954	.0809
0.6	15.4	16.1	(0.17)	.945	.0809
0.7	20.9	21.9	(0.20)	.936	.0796
0.8	27.9	29.0	0.23	.927	.0794
0.9	36.5	37.9	(0.27)	.918	.0798
1.0	45.7	47.7	0.315	.908	.0796

SOLUBILITY OF *N*-CHLOROACETANILIDE

(in g. mols. per litre).

In water ..		0.01390	
	0.4 <i>M</i>	0.7 <i>M</i>	1.0 <i>M</i>
In KCl ..	0.01208	0.01092	0.00988
KNO <sub>3</sub> ..	0.01344	0.01308	0.01268
HNO <sub>3</sub> ..	0.01592	0.01774	0.01998

Since it may be argued that the constancy of  $K$  may be fortuitous owing to the small range over which  $\gamma_{\text{HCl}}$  varied (0.755–0.810) experiments were conducted in more dilute acid solution with a variation of  $\gamma_{\text{HCl}}$  from 0.76 to 0.91, but in order to obtain reaction in a reasonable time, the experiments were conducted at 55°, with the following results.

TABLE II.

REACTION RATES IN HYDROCHLORIC ACID SOLUTION AT 55°.

<i>M</i> -HCl ..	0.01	0.02	0.05	0.1	0.2	0.3
$k_1 \times 10^3$ ..	0.32	0.86	3.7	11.2	43.7	99.7
$k_2 \times 10^3$ ..	0.19	0.37	0.92	1.74	3.18	4.3
$K$ ..	15.9	16.7	16.3	15.0	17.2	18.5

The factor  $\gamma_{\text{NaCl}}$  is negligible at these concentrations. Whilst these figures are not as accurate as those at 25° the results afford definite evidence in favour of the activity rate hypothesis.

*The Neutral Salt Effect.* Determinations were made of the rate of reaction in the presence of phenol, (1) at constant acid strength (0.01 *M*-HCl) and an amount of potassium chloride varying from 0.1 to 1.5 *M* and (2) in a solution of hydrochloric acid and potassium chloride such that the total molality was constant at 1 *M*, there being in this case a simple law relating the activity coefficient of the acid to its concentration (Harned, 1926).

TABLE III.

REACTION RATES IN THE PRESENCE OF NEUTRAL SALT AT 25°.

0.1 *M*-HCl + *x M*-KCl.

[KCl]	$k_2 \times 10^3$	$k_3 \times 10^3$	$\gamma_{\text{NaCl}}$	$K$
0.1	0.82	0.031	1.036	0.0677
0.2	1.14	.028	1.073	.0641
0.3	1.50	.025	1.119	.0615
0.5	2.06	.021	1.202	.0551
0.9	3.21	.016	1.370	.0452
1.0	3.47	.015	1.404	.0429
1.5	4.95	.012	1.598	.0343

Constant total molality of 1 *M*.

[KCl]	$k_2 \times 10^3$	$k_3 \times 10^3$	$\gamma_{\text{NaCl}}$	$K$
0.	47.7	0.315	0.908	0.0796
0.25	31.7	.164	1.036	.0669
0.5	18.8	.090	1.155	.0573
0.75	8.57	.040	1.282	.0506
0.9	3.21	.0162	1.370	.0459

Although there may be some doubt as to the value of  $\gamma_{\text{NaCl}}$  in these cases, the data recorded in the above table, using the  $\gamma_{\text{HCl}}$  values given by Harned and Åkerlöf (1926), cannot be reconciled with the activity rate hypothesis.

*The Temperature Coefficient.*

Separate experiments in nitric and perchloric acid solution showed that the temperature coefficient of the hydrolytic side-reaction corresponded to an energy of activation of 19,400 cal. The temperature coefficient of the main reaction is of the same order and therefore will not be affected appreciably by the side reaction.

TABLE IV.  
TEMPERATURE COEFFICIENT OF THE REACTION RATE.

	Solution.	15°	25°	35°	45°	55°	E
$k_1 \times 10^3$	0.3 M-HCl	.. 1.205	4.10	12.3	36.4	99.1	20,650
	0.2 M-HCl + 0.3 M KCl	.. 1.13	3.69	11.4	34.5	97.6	20,950

The energy of activation may be taken as 20,800 cal.

## DISCUSSION.

According to equation (5) the hydrolytic side reaction should involve collision between anilide molecules, hydrogen ions and solvent molecules.

Application of the usual formula :

$$k_s = \frac{N_o}{1000} \sigma^2 \sqrt{\left\{ 8\pi RT \left( \frac{1}{M_1} + \frac{1}{M_2} \right) \right\}} e^{-E/RT} \quad (6)$$

for the reaction rate in terms of molecular radii and velocities, on the assumption that reaction is caused by binary collisions of activated molecules leads to a calculated velocity constant some 1300 times larger than the observed. We may assume a probability factor of a reasonable magnitude to allow for this, but alternatively we may note that the kinetics of the reaction according to equation (5) necessitate the participation of water molecules in the binary collisions. In this respect the reaction resembles the iodination of  $\beta$ -phenylpropionic acid (Moelwyn-Hughes and Legard, 1933) and the decomposition of hydrogen peroxide catalysed by iodide ion (Hender and Robinson, 1933), and the equation which was found applicable in these cases should apply here:

$$k_2 = \frac{N_o}{1000} \frac{3 \pi \eta \sigma}{2m_A n_W} e^{-E'/RT}$$

where  $N_o$  is Avogadro's Number,  $\eta$  is the solvent viscosity,  $\sigma$  the mean diameter,  $m_A$  the molecular mass of one of the reacting species,  $n_W$  the number of solvent molecules per c.c. and  $E'$  is the energy of activation corrected for a viscosity variation. Although the theoretical basis of this equation may be somewhat insecure, its success in a number of applications justifies its use as an empirical indication that solvent molecules participate in the reaction. It is therefore encouraging to find that, using the corrected value  $E' = 23,350$  cal. the calculated value of the velocity constant is in reasonable agreement with that found experimentally. There is, indeed, no difficulty in accounting for the kinetics of this reaction.

Turning now to a consideration of the main reaction we have two problems, (1) the neutral salt effect and (2) the temperature coefficient. If we adopt the view that the acid catalyst is for all practical purposes completely dissociated, then we can only conclude

that in the presence of neutral salts there is a "primary neutral salt effect" in a negative direction and leave a further explanation until more is known about the general question of primary salt effects. On the other hand, it has been claimed that this anomaly can be removed by assuming that catalysis is due to undissociated acid molecules. This view can be shown to be erroneous, for let  $K_A$  be the acid dissociation constant, then

$$K_A = \gamma_H \gamma_{Cl} \frac{C_H C_{Cl}}{C_{HCl}}$$

since the activity coefficient of the undissociated molecule may be taken as unity. The rate of reaction is now given by:

$$\begin{aligned} -d[A]/dt &= k[A] C_{HCl} \\ &= k'' [A] \gamma_H \gamma_{Cl} C_H C_{Cl} \end{aligned}$$

This view, therefore, leads to an equation identical with that which is deduced on the assumption of complete dissociation; in fact, the two postulates cannot be distinguished by experiments at a single temperature.

The temperature coefficient of the reaction may, however, distinguish between the two postulates. Before proceeding further with the argument, it will be necessary to make some assumption as to the number of ternary collisions which can occur in a given time. The number of binary collisions per c.c. per sec. is:

$$Z_{12} = n_1 n_2 \sigma^2 \sqrt{\left\{ 8 \pi R T \left( \frac{1}{M_1} + \frac{1}{M_2} \right) \right\}}$$

where  $M_1$  and  $M_2$  are molecular weights and  $n_1$  and  $n_2$  the number of molecules of each species per c.c.

A ternary collision will occur if at the moment of impact the third molecule is within a specific distance  $r$  of the complex formed by the first two molecules. The probability of this is  $\frac{3}{4} \pi r^3 n_3$ , so that:

$$Z_{123} = \frac{4}{3} \pi n_1 n_2 n_3 r^3 \sigma^2 \sqrt{\left\{ 8 \pi R T \left( \frac{1}{M_1} + \frac{1}{M_2} \right) \right\}}$$

where  $n_3$  is the number of molecules of the third kind per c.c.

The number of molecules decomposing per c.c. per sec. is then:

$$-dn/dt = \frac{4}{3} \pi n_1 n_2 n_3 r^3 \sigma^2 \sqrt{\left\{ 8 \pi R T \left( \frac{1}{M_1} + \frac{1}{M_2} \right) \right\}} P e^{-E/RT}$$

$P$  being an orientation factor which is probably low for trimolecular reactions. Consequently:

$$k_3 = 80 \pi \left( \frac{N_0}{1000} \right)^2 r^3 \sigma^2 \sqrt{\left\{ 8 \pi R T \left( \frac{1}{M_1} + \frac{1}{M_2} \right) \right\}} P e^{-E/RT}$$

The data of Stern (1904) for the polymerisation of benzaldehyde in the presence of cyanide ions are given by:

$$k_3 = 3.16 \times 10^7 e^{-13000/RT}$$

Similarly the data of Bailey (1930) on the reaction between ammonia and ethyl malonate are given by:

$$k_3 = 2.46 \times 10^8 e^{-8620/RT}$$

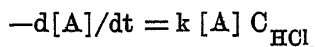
These reactions can be brought into line with the above equation, assuming reasonable molecular diameters,  $r = \sigma = 5 \text{ \AA}$ , if  $P$  is of the order of  $10^{-5}$ .

These calculations have no claim to accuracy, but they serve to demonstrate that termolecular reactions in solutions can be accounted for, at least qualitatively, the point to be emphasised being that the observed rate is lower than the calculated, as would be expected in view of the peculiar orientation of molecules necessary for such reaction. The decomposition of *N*-chloracetanilide can be represented by the equation:

$$k_3 = 10^{14} e^{-20800/RT} \quad (7)$$

whereas the calculated value of the collision factor is of the order of  $10^{12}$ . Since errors in our theory will tend to give too high a value to this collision factor, we may conclude that our results are not consistent with the hypothesis of ternary collision.

It may be, however, that reaction occurs between anilide molecules and undissociated acid molecules according to the approximate equation:



in which case  $k$  should be capable of calculation by means of equation (6). An approximate estimate of the dissociation constant of hydrochloric acid has already been made (Robinson, 1936) and thence we may calculate the following values for  $C_{\text{HCl}}$  in 0.3 *M* solution at different temperatures whilst the experimental data for the rate of reaction gives values of  $k$  as follows:

$^{\circ}\text{C}$	..	15	25	35	45	55
$C_{\text{HCl}} \times 10^3$	..	2.49	6.92	18.4	46.2	105
$k \times 10^{-4}$	..	4.8	5.9	6.7	7.9	9.5

These velocity constants can be represented by the equation:

$$k = 8 \times 10^6 e^{-20800/RT}$$

with an experimental value for the collision factor of  $8 \times 10^6$ , whilst the value for the collision factor calculated by equation (6) is of the order  $10^{18}$ . This implies that only one in about  $10^6$  of the activated collisions is effective, but it is encouraging to find that the value from the experimental data is less than the calculated, as would be expected for a reaction of this type; indeed, Rolfe and Hinshelwood (1934) found a probability factor of  $10^7$  for the esterification of methyl alcohol catalysed by undissociated acetic acid molecules. We have therefore a reasonable hypothesis to account for the temperature coefficient of this reaction. We may be tempted to identify these undissociated hydrochloric acid molecules with the "ion pairs" of Bjerrum's association hypothesis, but that such is unlikely may be shown by a consideration of the energy magnitudes involved. The energy liberated when an ion pair is formed is of the order of  $2 \text{ k T}$ ,

*i.e.*, about 1200 calories per gram-molecule (*vide* Fuoss and Kraus, 1933), whereas the undissociated molecules we are considering are formed with an absorption of about fifteen times as much heat, *i.e.*, a greater part of the apparent energy of activation is really the energy necessary for the formation of these undissociated molecules. Again, according to Harned and Ehlers, the mean diameter of the hydrogen and chlorine ions is 4.3 Å and it is doubtful if under these conditions any ion pairs can be formed. For this reason we do not believe that ion pairs function as the catalyst; but that undissociated molecules exist in very small amount, formed by means of a covalent bond in equilibrium with similar molecules in the gaseous phase.

Finally, if we adopt Brönsted's view (1922) that the rate of reaction is governed by the formation of a "critical complex," it can be shown that the neutral salt effects observed in this reaction, whilst not explicable quantitatively, are at least not inconsistent with the activity rate hypothesis. For on Brönsted's theory the rate of reaction will be given by:

$$-d[A]/dt = k_1[A]C_H C_{Cl} \gamma_H \gamma_{Cl} \frac{\gamma : NCl}{\gamma_X}$$

where  $\gamma_X$  is the activity coefficient of the "critical complex." The introduction of this additional factor will not influence to any serious extent the validity of the argument we have already pursued with regard to the temperature coefficient of this reaction for  $\gamma_X$  will not vary greatly with temperature, but its variation with the addition of neutral salts will be important. Now it will be reasonable to postulate that  $\gamma_X \gamma : NCl$  will vary in a similar manner with the ionic strength of the solution; thus, without assuming identity of  $\gamma_X$  and  $\gamma : NCl$  it is reasonable to believe that if  $\gamma : NCl$  is large and positive then  $\gamma_X$  will also be positive and of comparatively large magnitude and *vice versa* if  $\gamma : NCl$  is negative, whereas if  $\gamma : NCl$  is nearly unity then  $\gamma_X$  also will not be far removed from unity. In the limiting case where  $\gamma_X = 1$  then Brönsted's equation reduces to equation (1) with the inclusion of  $\gamma : NCl$  an equation which we have substantiated in the absence of neutral salts. The coincidences of these two equations would depend therefore on the close approach of  $\gamma_X$  to unity in pure hydrochloric acid solution; this is probable since  $\gamma : NCl$  is not far removed from unity. In potassium chloride solution however the observed values of the "constant"  $K$  in Table III diminish with increasing salt concentration which would be expected if  $\gamma_X$  increased with addition of salt, a hypothesis which is also probably correct since  $\gamma : NCl$  undergoes a considerable increase under these circumstances. A similar behaviour was observed by Dawson and Millet in sodium chloride solution. Data have also been obtained for sodium nitrate and perchloric acid solutions, but these are not susceptible to treatment in the absence of activity coefficient data for hydrochloric acid in these solutions. We may conclude, however, that, viewed in the light of Brönsted's theory, there is nothing in these neutral salts effects which can be demonstrated to be contrary to the activity rate theory.

## SUMMARY.

The rate of isomerisation of *N*-chloracetanilide by hydrochloric acid has been investigated and two side reactions taken into account. The neutral salt effect and the temperature coefficient have been studied.

The high temperature coefficient of the reaction has been shown to be consistent with catalysis by undissociated hydrochloric acid molecules.

No evidence has been found inconsistent with the activity rate hypothesis.

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## An Iodine Survey of New Zealand Livestock.

### Part V—Sheep of the North Island.

By D. F. WATERS.

[*Read before the Wellington Philosophical Society, October 26, 1938; received by the Editor, November 2, 1938; issued separately, June, 1939.*]

THIS survey was commenced in the South Island, where trouble with goitre is more common, the results being published by Mason (1933), Mason and Waters (1936), and Waters (1938). This paper, the last of the series, completes the survey of New Zealand supplementing the work of Sykes (1934) in the North Island.

The aim and method of the work has been explained in the papers mentioned and is summarised as follows:—Prompted by the occurrence of sporadic cases of goitre in farm animals, the survey of iodine available naturally to stock was based on the iodine content of thyroid glands of lambs. Samples, each of six glands, were taken at freezing works from drafts of lambs which could be traced back to single farms where the lambs were bred and fattened and where no iodized licks were used. Each sample was analysed separately, according to the method of von Fellenberg modified by Leitch and Henderson, and the iodine content expressed as a percentage of the dry weight of the glands. Field officers of the Department of Agriculture marked the position of the farms sampled on a large scale map.

As in Part IV of the series, the provinces have been divided into naturally bounded districts and further subdivided into farming areas. Districts such as Hastings, from which a large number of samples were received, were subdivided into small areas. Larger areas were chosen in districts represented by fewer samples, except where a marked difference in iodine level occurred or where the samples were too widely separated to be fairly designated as a farming area. For each farming area the averages of the percentages of iodine and the dry weights of the glands are given in the tables below. Results for each farm have been placed in iodine percentage groups broadly described as very low, low, fair, high and very high. More detailed figures are not justified, as considerable variation is found even in glands from one farm. For any area the distribution of samples between the iodine percentage groups gives a picture of the level of iodine as well as the degree of uniformity of the iodine supply in that area.

Each province has been presented separately and discussed briefly. Unfortunately, in many of the districts dairy farming is the principal industry and the majority of lambs were "bought in" for fattening. These districts are therefore represented by fewer glands than would be desired and the areas are not covered completely.

## WELLINGTON.

TABLE I.

Farming Areas.	Classification of Samples.					Average for Area.	
	V. low up to .09	Low .10 to .19	Fair .20 to .29	High .30 to .39	V. high .40 and over	Iodine per cent. dry wt.	Dry wt. per gland grams.
Manawatu-							
Wanganui							
Manawatu ..	4	11	—	—	—	.12	.93
Rangitikei ..	2	13	—	1	—	.14	.75
Wangaehu ..	3	3	1	—	—	.13	.81
Totals and mean	9	27	1	1	—	.13	.83
West Coast (ex- cluding above)							
Wellington ..		2	1	2	—	.23	1.03
Otaki .. ..		4	2	1	—	.22	.61
Levin .. ..		1	5	—	—	.23	.67
Taihape .. ..	2	4	5	4	—	.23	.58
Kai-iwi .. ..		2	1	—	—	.22	.63
Waverley ..		4	11	3	—	.23	.49
Totals and mean	2	17	25	10	—	.22	.51
Wairarapa							
Pahiatua ..			7	—	1	.26	.59
Alfredton ..			2	1	1	.32	.45
Tinui .. ..			2	—	1	.32	.59
Masterton ..		4	2	3	1	.26	.61
Martinborough		1	—	1	—	.26	.42
Totals and mean		5	13	5	4	.27	.56

## WEST COAST.

This district is mainly devoted to dairy farming and many of the sheep are bred on the hills and moved to the flats for fattening. The few glands collected show a marked difference in iodine content between samples from the Manawatu-Wanganui plain and those from the rest of the district. Of 38 samples from Manawatu, Rangitikei and Wangaehu, nine are very low and only two are above .20 per cent. iodine. In the other areas the samples fall into the higher groups, although Taihape is an area with considerable variation in iodine supply and samples are found in each of the lower groups. The average for the whole district is rather low, mainly due to the figures obtained for the low iodine areas mentioned. The average for these areas, estimated separately, is 0.13 per cent., which is comparable with results from low areas in the South Island where goitre is known, with the difference that no enlarged glands have been reported in the Manawatu-Wanganui areas. It is notable that no glands from the district contained 0.40 per cent. iodine or more.

## WAIRARAPA.

This district has already been surveyed by Sykes (1934). A few more samples were taken in the area and show it to be fairly high in iodine.

## TARANAKI.

TABLE II.

Farming Areas.	Classification of Samples.					Average for Area.	
	V. low up to .09	Low .10 to .19	Fair .20 to .29	High .30 to .39	V. high .40 and over	Iodine per cent. dry wt.	Dry wt. per gland grams.
Patea .. ..			3	1		.27	.45
Hawera .. ..			3			.26	.45
Inglewood ..				4		.33	.58
Waitara .. ..		1	4	4	2	.31	.48
Totals and mean		1	10	9	2	.30	.49

This also is principally a dairying province and suitable samples were difficult to obtain. The samples shown above were small glands uniformly high in iodine. An attempt was made to supplement the samples by using glands taken from "bobby" calves, but the method of railing the calves made it impossible to trace them back to the farms with any degree of certainty. The average iodine content of the 30 samples of calf thyroids analysed was 0.37 per cent. on the dry weight. This bears out the conclusion that the province is well supplied with iodine.

## AUCKLAND.

TABLE III.

Farming Areas.	Classification of Samples.					Average for Area.	
	V. low up to .09	Low .10 to .19	Fair .20 to .29	High .30 to .39	V. high .40 and over	Iodine per cent. dry wt.	Dry wt. per gland grams.
King Country-							
Waikato							
Taumarunui ..			1	1		.27	.48
Te Kuiti .. ..		2	7	6	1	.29	.48
Otorohanga ..					3	.43	.49
Te Awamutu ..		1	2	6	5	.38	.54
Raglan .. ..			2	1	3	.37	.47
Hamilton .. ..	1	7	7	4		.23	.62
Morrinsville ..	1	2	15	7	1	.27	.51
Tauranga .. ..			1	1	1	.37	.47
Mercer .. ..		1	2			.23	.64
Totals and mean	2	13	37	26	14	.29	.53
North Auckland							
Dargaville ..			9	5	2	.32	.57
Whangarei ..		1	3	1	1	.26	.74
Kaikohe .. ..		1	11	10	1	.29	.63
Kaitaia .. ..		1	8	10	2	.30	.71
Totals and mean		3	31	26	6	.30	.65
Gisborne							
Hicks Bay ..		1	2	1		.24	.62
Tokomaru Bay			4	2	1	.30	.64
Tolaga Bay ..		2	4	1	1	.28	.71
Rakauroa ..		1	1	1		.22	.70
Pouawa .. ..		1		1		.25	.49
Te Karaka ..		2	1			.20	.46
Patutahi ..		2	5	2	2	.24	.49
Totals and mean		9	17	8	4	.27	.61

## KING COUNTRY, WAIKATO AND TAURANGA.

The figures for this district are high with the exception of samples from Hamilton and Mercer, which are about average. There appears to be a small area near Taupiri where the iodine level is much lower. Recently some very enlarged glands were taken from sheep in this area which gave the following figures:—

Wet weight of gland.	Dry weight of gland.	Iodine percentage on dry weight.
179 grams	37 grams	0.0086
715 grams	131 grams	0.0052

Glands from sheep in the immediate vicinity of this farm were also shown to be low in iodine, but not so grossly enlarged.

The glands received from Otorohanga, Te Awamutu, Raglan and Tauranga were exceptionally high in iodine.

## NORTH AUCKLAND.

The district is well supplied with iodine, the glands being uniformly high. Only 3 in 66 samples were below 0.20 per cent., while only six were above 0.40 per cent.

## GISBORNE.

A slightly lower average is found in this district, and proportionately more of the glands fall into the "low" classification. No glands are deficient, and the level of iodine in the district is satisfactory.

## HAWKES BAY.

TABLE IV.

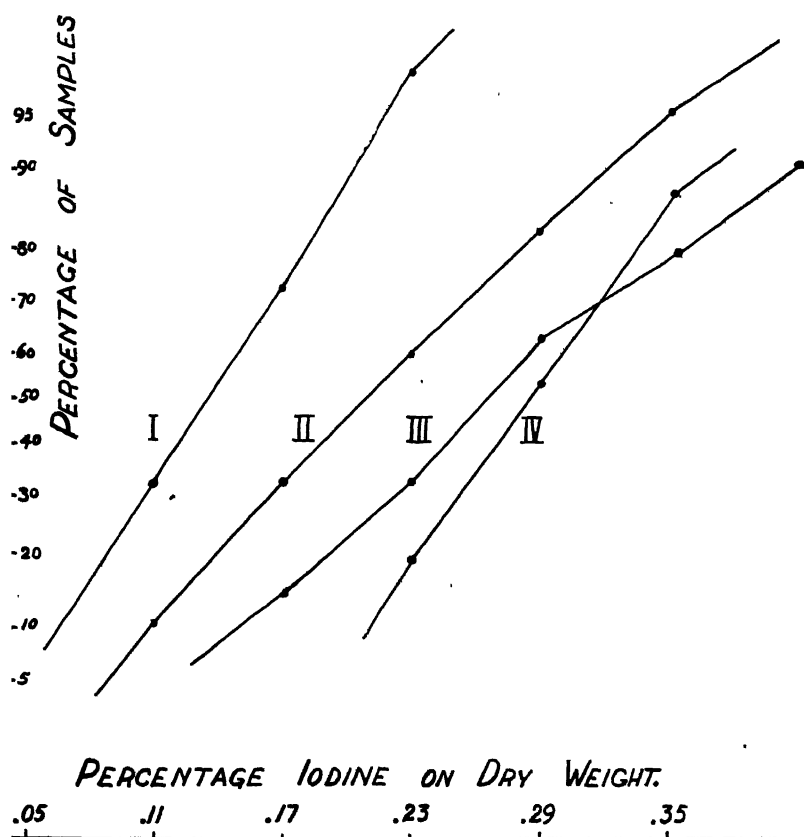
Farming Areas.	Classification of Samples.					Average for Area.	
	V. low up to .09	Low .10 to .19	Fair .20 to .29	High .30 to .39	V. high .40 and over	Iodine per cent. dry wt.	Dry wt. per gland grams.
Waikaremoana ..		1		2		.27	.71
Wairoa .. ..		4	5			.21	.07
Eskdale .. ..		4	3	3	1	.26	.65
Sherendon ..	1	6	5	1		.19	.72
Maraekakaho ..		6	8	1	2	.24	.74
Hastings .. ..	1	3	2			.16	.61
Waimarama ..	1	3	3	3		.22	.61
Opapa .. ..		2	4	1		.24	.82
Waipawa .. ..	3	11	5	2	1	.19	.68
Porangahau ..		2	3	2		.25	.62
Waipukurau ..	2	11	7	1		.17	.72
Ongaonga .. ..	2	7	4	3		.20	.82
Takapau .. ..	1	10	5	6	1	.24	.63
Totals and mean	11	70	54	25	5	.21	.70

As this province is largely devoted to sheep farming, a large number of samples was available and the farming areas were covered fairly completely. The level of iodine is lower than in Auckland and Taranaki, and resembles Wellington fairly closely. There is a high proportion of deficient glands in the areas Sherendon, Hastings, Waipawa, and Waipukurau, but the data on hand did not show any correlation between iodine level and geological formation.

## GRAPHICAL PRESENTATION OF RESULTS.

For comparison with South Island results accumulative distribution diagram has been prepared. This is a modification of the ogive in which the scale is so adapted that normal distribution results in a straight line.

Each point shown represents the percentage of samples falling on or below that level of iodine. The more upright the curve the closer the limits of variation.



The four curves shown have been selected as representing the districts surveyed with sufficient accuracy.

*Curve I. Manawatu-Wanganui Area.*

The curve is straight, showing an even distribution, and steep, showing the narrow range of the iodine content of the samples. About one-fifth of the glands are below 0.10 per cent. and only one-tenth above 0.19 per cent. iodine, and the median corresponds with 0.13

per cent. iodine. The area is lower in iodine than other districts in the North Island and similar to Westland and Southland, which gave a very similar curve.

#### *Curve II.*

This curve is given by samples from the West Coast of Wellington Province other than the areas dealt with in Curve I, and may be taken to represent Hawke's Bay samples. Here a wider variation in iodine level is apparent from the flat curve. One-twentieth of the glands are below 0.10 per cent., one-tenth are above 0.33 per cent., and the median at 0.21 per cent. iodine. The curve is similar to that for Canterbury.

#### *Curve III. Wairarapa Samples.*

Very similar curves are given by Waikato and Gisborne samples. This shows a similar wide variation in supply, but a higher level of iodine in these areas than in the areas represented by Curve II. The number of glands below 0.10 per cent. is negligible, while one-tenth contain above 0.41 per cent. and the median is about 0.27 per cent. iodine. Nelson, Marlborough, Banks Peninsula, and Otago give similar curves.

#### *Curve IV. North Auckland Samples.*

Taranaki samples gave an almost identical curve. The curve shown is fairly upright, showing the uniform conditions which exist in these districts. No samples are below 0.20 per cent., yet nine-tenths are below 0.37 per cent. iodine. These areas, while not giving any glands with very high iodine content, have on the whole a better and more uniform supply than other areas in New Zealand.

### SUMMARY.

The iodine content of 464 samples of lamb thyroids shows the North Island to be generally well supplied with iodine.

The Manawatu-Wanganui plain is the only area low in iodine and may be placed in the same class as Westland and Southland. No enlarged glands, however, have been received from the area.

The West Coast of Wellington Province, excluding the area just mentioned, and Hawke's Bay are fair in available iodine and resemble the Canterbury Plains.

The Wairarapa, Waikato and Gisborne areas are well supplied with iodine and are comparable with Nelson, Marlborough and Otago.

Taranaki and North Auckland are uniformly high in iodine.

### ACKNOWLEDGMENTS.

The author wishes to express his thanks to Mr. B. C. Aston, late Chief Chemist, Department of Agriculture, under whose direction this survey was commenced, and to Mr. R. E. R. Grimmett,

Chief Agricultural Chemist, who facilitated the completion of the work. The officers of the Livestock Division contributed invaluable assistance in collecting and forwarding samples and data. Many of the analyses were the work of Messrs. P. H. Sykes and F. A. Denz, late of the Department of Agriculture.

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## Mineralogical Notes from the University of Otago, New Zealand—No. 2.

### COMPARATIVE COMPOSITION-VARIATION DIAGRAMS FOR THE CAINOZOIC IGNEOUS ROCKS OF NEW ZEALAND WITH DETERMINATIONS OF THE OPTIC AXIAL ANGLES OF THE PYROXENES AND OLIVINES CONTAINED THEREIN.

By W. N. BENSON AND F. J. TURNER.

[Read before Otago Branch, September 13, 1938; received by the Editor,  
October 14, 1938; issued separately, June, 1939.]

#### MATERIAL STUDIED.

ATTENTION has lately been given to the composition of pyroxenes in basic lavas in the Pacific region and in other parts of the world, and its significance in petrogenesis has been much discussed (e.g., by Barth 1931, Tsuboi 1932, Kennedy 1933, and Kuno 1936). To test the extent to which the generalisations that have been advanced may be applied to the Cainozoic lavas of New Zealand, the optic axial angles of pyroxenes and olivines have been measured in the case of thirty-nine representative rocks from three regions.

In order to indicate quantitatively the general character of the petrographic association in each of these regions, two variation diagrams are given which have been based on the available good analyses of New Zealand Cainozoic lavas, nearly two hundred in all, of which the greater proportion are the work of F. T. Seelye, while of the remainder, including most of those from the Dunedin District, the majority are the work of Dr. P. Marshall. Of the two diagrams, Fig. 1 shows the conventional smoothed-curve variation diagram of the principal oxides in A the lavas in the North Island, B the lavas of Banks' Peninsula, D the lavas of the Dunedin district free from essential amounts of modal feldspathoids and/or alkaline pyroxene, and D.1 Dunedin lavas of a more alkaline character. Figures 2 and 3 show the actual distribution of points in the plotting of the analyses used in obtaining the smoothed variation curves for calc-alkaline and alkaline igneous rocks of the Dunedin district. Figure 4 illustrates the variation of the norm-compositions calculated from the analyses utilised in preparing the curves A, B, and D in Figure 1. Separate curves are given for the lavas of the North Auckland Peninsula and the vicinity of Auckland City (A1), for the south-east of the Auckland Province (Cape Colville Peninsula and the Rotorua-Taupo region) (A2), and for the south-west of the Auckland Province and Taranaki (A3). Figure 5 illustrates for the Late Cainozoic rocks of Banks' Peninsula the distribution of points in the plotting of the norm-compositions on which the smoothed variation curves were drawn. (The Akaroa syenite probably does not belong to this rock-series.)

Broadly characterised the first of these areas (see *N.Z. Geological Survey Bulletins*, Nos. 8, 27, 34) possesses a basement of highly folded Mesozoic greywacke and argillite partially covered by

Cretaceous and Tertiary sandstones, mudstones, and occasionally limestones. The effusive rocks are Mid-Tertiary rhyolites, dacites and pyroxene-andesites, Lower Pliocene olivine-andesite, dacite and rhyolites, and widespread Late Pliocene to Recent basalts. The latter alone occur in the Auckland urban area, and have slightly alkaline features as shown by the occasional presence of *normative* (not modal) nepheline, and a small mass of pegmatoid nephelinite ("luscladite") in a single locality. The only rocks from the North Island in which the optic axial angles have been determined by the writers are from this basaltic group. In the South-eastern portion of the Auckland Province (see *N.Z. Geological Survey Bulletins*, Nos. 4, 15, 16, 26, 37) the cover of Cretaceous sediments above the folded Mesozoic greywackes is lacking, and that of the Tertiary sediments is relatively thin or absent. In the Cape Colville Peninsula the sequence of volcanic eruptions is broadly Miocene andesites, dacites and rhyolites, Late Miocene andesites, quartz-andesites and dacites, and Pliocene to Early Pleistocene rhyolites, each division containing fragmental as well as massive ejectamenta. In the Rotorua-Taupo region the record is more varied, Miocene andesite being followed by Pliocene andesite, dacite and subordinate basalts, while Pleistocene rhyolite and very subordinate basaltic eruptions also have continued into Recent times. In South-west Auckland and Taranaki (see *N.Z. Geological Survey Bulletins*, Nos. 14, 14, 28, 29) there is commonly, though not always, a very thick cover of Tertiary marine sediments above the Mesozoic greywackes. A small amount of Miocene andesite and tuff occurs, but in the North are Late Pliocene to Recent olivine-andesites and weakly alkaline olivine-basalts, and in the South-west varied Late Pliocene to Pleistocene andesites. Optic axial angles of the pyroxenes in the various andesites and dacites of the above regions have not yet been measured, and it is hoped to extend these studies to deal with them as opportunity offers.

On Banks' Peninsula the basement rocks are also folded Mesozoic greywackes, upon the eroded surface of which rest basalts and andesites of probably Late Mesozoic age followed in turn by a little Mid-Tertiary sandstone and still younger rhyolites and pitchstones. The Late Cainozoic basalts and andesites that make up the bulk of Banks' Peninsula (see Speight, 1917, 1922, 1923, 1924, 1926, 1936, 1938) lie upon the eroded surface of these rocks. The basalt is on the average rather more alkaline than that of the North Island, and occasionally the analyses indicate a little normative nepheline though the mineral is never seen modally. The volcanic series ranges up through basalt and dolerite to olivine-andesite, and is cut by trachytic dykes, some of which contain alkaline amphibole and approach phonolite in composition. Except in the case of trachytes containing possibly deuteric tridymite, none of the Late Cainozoic igneous rocks contains free silica.

The volcanic rocks of the Dunedin district rise through quartz-albite-chlorite-sericite-epidote-schists (derivatives of greywackes and argillites), and through part or all of the superimposed Cretaceous to Mid-Tertiary sandstones and mudstones, which are more or less calcareous in the upper portions. The range of rock-types is wider

than in the other districts, for not only are there dolerites, basalts, trachybasalts, trachyandesites and trachytes free from distinctly alkaline minerals (see Fig. 2 for norm-variation) but also, in repeated association with the above, a more variable and distinctly alkaline series of ankaramites, kulaites, basanites, tinguaites, phonolites, etc., including hybrid and transitional rock-types, the compositions of which are too widely diverse to be indicated by any one series of curves (cf. Benson, 1934) such as those in Fig. 4.

The average composition of the Dunedin basalt is close to that of Banks' Peninsula, the chief differences being in the relative abundance of iron and magnesia. The average North Island basalt is clearly less alkaline, less titaniferous, and more calcic than that of Banks' Peninsula. This appears from the following table in which the second column of figures for Banks' Peninsula basalt includes five rocks classed as olivine-andesites. The averages may be compared with those for the olivine-labradorite-basalts of Victoria (Edwards 1938) and for those of the Pacific (Tyrrell 1937).

	Dunedin.	Banks' Peninsula.		N. Island.	Victoria.	Pacific.
Analyses.	19	14	19	19	20	17
SiO <sub>2</sub> ..	48.18	49.14	49.17	49.33	49.78	47.6
Al <sub>2</sub> O <sub>3</sub> ..	16.10	15.71	16.10	15.64	14.60	14.5
Fe <sub>2</sub> O <sub>3</sub> ..	6.02	3.64	3.79	5.47	4.09	3.6
FeO ..	8.71	8.17	7.90	6.47	7.55	8.2
MgO ..	3.90	6.03	5.62	7.75	8.77	7.0
CaO ..	9.89	8.38	8.40	10.22	8.65	10.0
Na <sub>2</sub> O ..	3.49	3.69	3.74	3.14	2.85	3.0
K <sub>2</sub> O ..	1.56	1.39	1.46	0.98	1.29	1.1
TiO <sub>2</sub> ..	2.31	3.17	2.95	0.90	1.85	3.2
P <sub>2</sub> O <sub>5</sub> ..	0.36	0.73	0.73	0.40	0.43	0.4
MnO ..	—	0.15	0.15	0.16	0.19	0.2

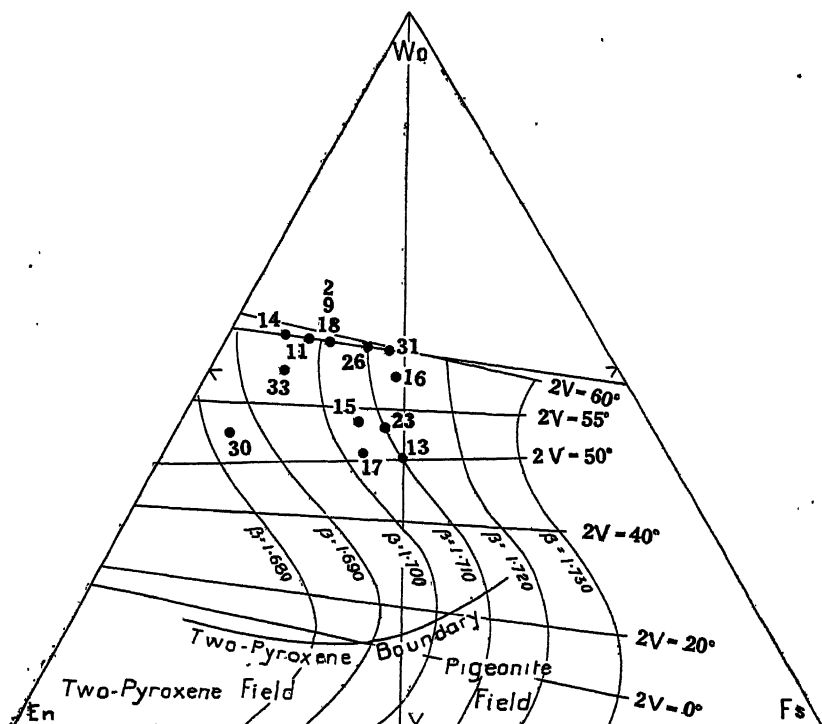
The normative mineral compositions calculated from these are as follows:—

	Dunedin.		Banks' Peninsula.			N. Island.		Victoria.		Pacific.	
Feldspar.		mol.		mol.	mol.		mol.		mol.		mol.
Or ..	8.90	10	8.34	10	8.90	10	6.12	7	7.78	10	6.7
Ab ..	28.8	35	30.92	38	31.44	38	26.72	35	24.10	32	27.9
An ..	23.91	55	21.98	52	23.80	52	25.30	58	23.07	58	21.7
Ne ..	...	%	0.28	%	...	%	...	%	...	%	...
	61.63		61.50		63.14		58.11		54.95		55.6
Pyroxene.											
Wo ..	9.51	50	6.50	50	6.15	36	9.51	37	7.31	23	10.7
En ..	5.20	32	4.20	37	7.10	46	12.20	53	16.20	62	8.8
Fs ..	3.96	18	1.85	13	3.56	18	2.90	10	5.68	15	3.6
	18.67		12.55		16.81		24.61		29.19		23.1
Olivine.											
Fo ..	3.15	64	7.63	74	4.90	73	5.04	84	4.06	78	6.0
Fa ..	2.45	36	3.78	26	2.65	27	1.22	16	1.63	22	2.9
	5.60		11.41		7.55		6.26		5.69		8.9
Mt ..	8.82		5.34		5.57		7.89		6.03		5.3
Il ..	4.41		6.08		5.46		3.65		3.50		6.1
Ap ..	10.1		1.68		1.68		0.67		1.01		1.0

From these figures it would appear that the average normative pyroxene in the basalts proper of Dunedin and Banks' Peninsula is mostly diopsidic, while that of the less alkaline North Island

basalts often approaches more nearly to pigeonite as Kennedy's (1933) discussion would suggest. It further appears that the average normative olivine is richest in iron in the basalts of Dunedin and poorest therein in those of the North Island. Comparing the individual norms of analysed basalts, the tendency for increase in the proportion of fayalite in the normative olivine with increasing silica, though not clearly marked, is suggested in the Dunedin analyses, and to a less extent in those from Banks' Peninsula, but is not at all evident among the basalts of the North Island. (See Fig. 4.) As will be seen, the optical measurements recorded below indicate compositions of pyroxenes and olivine departing considerably from those calculated normatively, and vary greatly among themselves. The presence of alumina and titanium in the pyroxenes and the effects of crystal-sorting probably contribute to this.

A preliminary investigation of the optic axial angles of the phenocrystic pyroxenes in the Dunedin basalts was made by one of us (W.N.B.) utilising the graphic method described by Becke (1895, 1904). About sixty angles were measured. They ranged chiefly between  $44^\circ$  and  $58^\circ$ , with a few lower (lowest  $38^\circ$ ) and a few reaching as high as  $60^\circ$ . It was not possible by the method employed to determine the optic axial angles of the individual layers in zoned



P-Q Two-Pyroxene Boundary.

Normative composition of pyroxenes in New Zealand basalts plotted on Kuno's (1936) diagram of the optic properties of monoclinic pyroxenes.

crystals or of the small groundmass pyroxenes or of the olivines. Subsequently a Leitz universal stage was obtained (with hemispheres of refractive index 1.554), and 220 measurements of optic axial angles were made by F. J. Turner, using the standard method as described by Nikitin (1936, pp. 32-38). The above total does not include those angles the measurement of which involved high angles of tilting and which were therefore discarded. The compositions of the olivines were deduced from the measured optic axial angles according to the curves given by Winchell (1933, p. 191) with which the data quoted by Bowen and Schairer (1935) are substantially in agreement. Means for the accurate determination of refractive indices permitting a closer approximation to the composition of the pyroxenes (see Figure 6) were not available.

The rocks studied were:—

(a) Basalts selected by Professor J. A. Bartrum as illustrative of the Pleistocene and sub-Recent olivine-basalts of the Auckland urban district and its vicinity as described by Firth (1930, pp. 112-120), Bartrum and Branch (1936, p. 404).

(b) A series of Late Cainozoic basalts and olivine-andesites selected by Professor R. Speight as representative of those of the Lyttelton volcano, Banks' Peninsula, as described by him (Speight, 1924, 1936). They are invaded by a series of trachytic dykes (Speight, 1936, pp. 307-10).

(c) The Pliocene dolerites, basalts, trachybasalts, trachy-andesites, kaiwekites [= hybrid olivine-trachytes (?)] and phonolites of the Dunedin district, now under investigation by one of us (W.N.B.), and including many rocks described by Marshall (1906, 1914), to whom we are especially indebted for the use of the slides illustrating his study (1914) of the series of flows on North Head.

#### LIST OF SECTIONS EXAMINED.

In the following list the number appearing on the slide label is given in brackets. References are also given to published analyses and descriptions where available.

##### *Auckland.*

1. Olivine-basalt; Karaka quarry, N. side of Paerata College, Auckland.
2. Olivine-basalt; Smeed's quarry, left bank of Waikato between Tuakau and Mercer, Auckland. Possibly represented by analysis No. 18, *N.Z. Geological Survey Bulletin*, No. 28, p. 70.
3. Olivine-basalt; Smaile's quarry, Takapuna, Auckland.
4. Olivine-basalt; Wiri Mountain, Auckland.
5. Olivine-basalt; West side of Ihumatea Mountain, Auckland.
6. Olivine-basalt; Little Rangitoto, Auckland.
7. Olivine-basalt; Rangitoto Island, Auckland.
8. Olivine-basalt; Urquhart's quarry, Patumahoe, Auckland.

##### *Banks' Peninsula.*

9. Olivine-basalt; Point Halswell quarry, Banks' Peninsula. For analysis see Speight, 1924, p. 252, No. 1.

10. Doleritic basalt; Dyer's Pass Road, Banks' Peninsula.
11. Olivine-basalt; Ahuriri Lagoon, Banks' Peninsula. For analysis see Speight, 1924, p. 252, No. 2.
12. Olivine-andesite; Garland's quarry, Banks' Peninsula.

*Dunedin District.*

13. Olivine-basalt; Flow No. 4, Otago North Head, Dunedin [Q4]. For analysis see Marshall, 1914, p. 394, No. 4.
14. Olivine-basalt; Otago North Head, Dunedin [Q9]. For analysis see *ibid.*, No. 6.
15. Basalt with little olivine; Flow No. 10, Otago North Head, Dunedin [Q14]. For analysis see *ibid.*, No. 10.
16. Olivine-basalt; Flow No. 11, Otago North Head, Dunedin [Q15]. For analysis see *ibid.*, No. 11.
17. Basalt with little olivine; Flow No. 16, Otago North Head, Dunedin [Q22]. For analysis see *ibid.*, p. 395, No. 16.
18. Basalt with little olivine; Flow No. 17, Otago North Head, Dunedin [Q23]. For analysis see *ibid.*, p. 395, No. 17.
19. Basalt with little olivine; Flow No. 23, Otago North Head, Dunedin [Q31]. For analysis see *ibid.*, p. 395, No. 23.
20. Olivine-basalt; East of Waironga, Dunedin [KI 3a, N.Z. Geological Survey].
21. Olivine-basalt; South of Jeffreys Hill, Dunedin [KI 29, N.Z. Geological Survey].
22. Olivine-dolerite; Nichol's Creek, Dunedin.
23. Olivine-dolerite; Kaikorai, Dunedin [42]. For analysis see Appendix.
24. Basanite; Mihiwaka, Dunedin [Q27].
25. Trachybasalt with little olivine; Dunedin [P89].
26. Trachybasalt with little olivine; Nevis St., Kaikorai, Dunedin [44]. For description (as andesite) see Marshall, 1906, p. 408. For analyses see Appendix.
27. Olivine-trachyandesite; Anderson's Bay, Dunedin [948].
28. Augite-trachyandesite; conglomerate, Otago North Head, Dunedin [N9].
29. Augite-trachyandesite; North-East Valley, Dunedin [P81].
30. Augite-trachyandesite; Bell Hill, Dunedin [D26]. For description (as augite-diorite or essexite) see Marshall, 1906, pp. 394, 422. For analysis see Appendix.
31. Phonolitic trachyandesite; Robin Hood quarry, Boys' High School, Dunedin [P69].
32. Trachyandesite; Dunedin [Ob 27].
33. Kaiwekite; Dunedin [H16]. For description and comparable analyses see Marshall, 1906, p. 400; 1914, pp. 390, 395; also Appendix.
34. Kaiwekite; Dunedin [D11].
35. Kaiwekite; Kaikai Beach, Dunedin [552].
36. Phonolite; Mopanui, Dunedin [D14]. For description and analysis see Marshall, 1906, p. 405.
37. Phonolite; Purakanui, Dunedin [I7]. For description and analysis see Marshall, 1906, p. 402.
38. Phonolite; Dunedin [4, Auckland University College].
39. Phonolite; Railway-cutting, Blueskin, Dunedin [P24].

## PYROXENES IN AUCKLAND BASALTS.

Rock Number.	Variety.	Mode of Occurrence.	2V.	sign.	Remarks.
1	Colourless augite	Small phenocrysts	62°	+	Subophitic
1	Colourless augite	Groundmass	50	+	
			51	+	
			52	+	
			54	+	
			64	+	
2	Titan-augite	Zoned phenocryst	62-58*	+	
2	Titan-augite	Groundmass	49	+	
			58	+	
			62	+	
3	Titan-augite	Small phenocrysts	50	+	
			64	+	
3	Titan-augite	Groundmass	60	+	
			62	+	
4	Augite	Small phenocryst	50	+	
4	Augite	Groundmass	54-47	+	
			52	+	
			52	+	
			52	+	
5	Titan-augite	Zoned phenocryst	52-46	+	
5	Titan-augite	Groundmass	52	+	
			59	+	
6	Titan-augite	Phenocrysts	54-67°	+	} Hour-glass structure
			52-60	+	
6	Titan-augite	Zoned phenocryst	62-46	+	
6	Titan-augite	Unzoned phenocrysts	45	+	
			62	+	
6	Titan-augite	Groundmass	62	+	
7	Augite	Phenocrysts	52	+	
			53	+	
7	Augite	Groundmass	46	+	
			49	+	
			50	+	
			50	+	
			58	+	
			60	+	
7	Enstatite	Groundmass	72	+	
7	? Hypersthene	Groundmass	88	—	Possibly Olivine
8	Augite	Phenocryst	54	+	
8	Augite	Groundmass	46	+	
			48	+	
			60	+	
Mean	Augite	Phenocrysts	55	+	14 measurements
Mean	Augite	Groundmass	54	+	26 measurements
Mean	Enstatite	Groundmass	72	+	1 measurement

\*In the case of zoned crystals the first figure refers to the central zone, the second figure to the marginal zone.

## PYROXENE IN LYTTTELTON BASALTS AND OLIVINE-ANDESITES.

Rock Number.	Variety.	Mode of Occurrence.	2V.	Sign.	Remarks.
9	Augite	Groundmass	60°	+	} Slender prisms
			62	+	
9	Ortho-pyroxene	Groundmass	82	+	
			84	—	
10	Titan-augite	Zoned phenocrysts	50-46	+	
			64-60	+	
10	Titan-augite	Unzoned phenocryst	52	+	
10	Titan-augite	Groundmass	52	+	
			54	+	
			56	+	
11	Augite	Zoned phenocrysts	57-65	+	
			50-60	+	
11	Augite	Groundmass	51	+	
			62	+	
12	Colourless augite	Phenocrysts	50	+	
			55	+	
12	Colourless augite	Groundmass	62	+	
Mean	Augite	Phenocrysts	55	+	7 measurements
Mean	Augite	Groundmass	57	+	8 measurements
Mean	Ortho-pyroxene	Groundmass	89	+	2 measurements

## PYROXENE IN DUNEDIN BASALTS.

Rock Number.	Variety.	Mode of Occurrence.	2V.	Sign.	Remarks.
13	Titan-augite	Phenocrysts	48° 50 54	+ + +	
13	Titan-augite	Groundmass	45 46 50 50	+ + + +	
13	Hypersthene	Groundmass	72	—	
14	Augite	Phenocrysts	50 52	+ +	
15	Titan-augite	Zoned phenocrysts	44 46	+ +	Same value in all zones
15	Titan-augite	Groundmass	64 66 68	+ + +	
16	Titan-augite	Phenocryst	54	+	
16	Titan-augite	Groundmass	42	+	
17	Augite	Phenocrysts	38 44 52 64	+ + + +	
17	Augite	Groundmass	56	+	
17	Ortho-pyroxene	Groundmass	86 89 90 90	+ + + —	
			76 78 78	— — —	} Prisms with positive elongation
18	Augite	Phenocrysts	51 54	+ +	
18	Ortho-pyroxene	Groundmass	76 77 80	— — —	
19	Augite	Phenocrysts	52 56	+ +	
19	Augite	Groundmass	56	—	
19	Ortho-pyroxene	Groundmass	84	—	
20	Titan-augite	Zoned phenocryst	50-44	+	
20	Titan-augite	Unzoned phenocryst	62	+	
20	Augite	Groundmass	53 58 62	+ + +	
21	Hypersthene	Small phenocrysts	72 72 72 72 88	— — — — —	} Groundmass. Pyroxene is indeterminate (very fine- grained)
22	Titan-augite	Zoned phenocryst	52-46	+	
		Unzoned phenocryst	46	+	
22	Titan-augite	Groundmass	58	+	
22	Enstatite	Groundmass	78	+	} Ophitic dolerites
23	Titan-augite	Groundmass	45 50 50	+ + +	
Mean	Augite	Phenocrysts	50.5	+	20 measure- ments
Mean	Augite	Groundmass	55	+	17 measure- ments
Mean	Ortho-pyroxene	Groundmass and small phenocrysts	81	—	18 measure- ments

## PYROXENE IN DUNEDIN BASANITES, TRACHYBASALTS, AND TRACHYANDESITES.

Rock Number.	Variety.	Mode of Occurrence.	2V.	Sign.	Remarks.
24	Titan-augite	Phenocrysts	48°	+	Basanite
			49	+	
24	Pale green augite	Phenocryst	70	+	
24	Pale green augite with colourless rim	Zoned phenocryst	70-53	+	
24	Bright green augite	Phenocryst	82	+	
25	Titan-augite	Groundmass	48	+	
			52	+	
25	Titan-augite	Phenocrysts	50	+	
			50	+	
			51	+	
			52	+	Trachy-basalts
25	Very pale green augite.	Phenocryst	68	+	
25	Enstatite	Small phenocryst	76	+	
25	Hypersthene	Groundmass	66	—	
			72	—	
26	Titan-augite	Zoned phenocrysts	68-60	+	
			58-50	+	
26	Titan-augite	Unzoned phenocrysts	56	+	
			60	+	
26	Titan-augite	Groundmass	56	+	
			57	+	Trachy-andesites
27	Titan-augite	Phenocrysts	62	+	
28	Titan-augite	Phenocrysts	46	+	
			54	+	
			58	+	
28	Titan-augite	Groundmass	60	+	
			60	+	
29	Colourless augite	Phenocryst	57	+	
29	Colourless augite	Groundmass	60	+	
30	Colourless augite	Groundmass	46	+	
			48	+	
			48	+	
			58	+	
32	Colourless augite	Phenocryst	52	+	

## PYROXENE IN DUNEDIN KAIWEKITES AND PHONOLITES.

Rock Number.	Variety.	Mode of Occurrence.	2V.	Sign.	Remarks.
33	Very pale green augite	Phenocrysts	58°	+	Kaiwekites
			60	+	
			68	+	
33	Very pale green augite	Groundmass	54	+	
34	Colourless augite	Phenocrysts	50	+	
			52	+	
			58	+	
			68	+	
35	Very pale green augite	Phenocrysts	59	+	
			60	+	Rimmed with optically negative aegirine
35	Very pale green augite	Groundmass	62	+	
36	Green aegirine-augite	Phenocryst	72	+	
37	Colourless augite	Central zones of phenocrysts	46	+	Rimmed with aegirine
			56	+	
37	Deep green aegirine	Outer zones of same phenocrysts	80	—	
			70	—	
38	Titan-augite	Phenocryst	62	+	
39	Titan-augite	Central zones of phenocrysts	48	+	
			50	+	
39	Deep green aegirine	Outer rim of second phenocryst	75	—	

## OLIVINE IN AUCKLAND BASALTS.

Rock Number.	2V.	Sign.	Remarks.
1	88-84°	—	Outer zone (84) narrow
	86	—	
2	86	+	
	88	—	
	90-85	—	Outer zone narrow
	84-88	—	Outer zone narrow
3	84	—	
	86	—	
	88	—	
4	87	—	
	90-84	—	Outer zone narrow
	86-90	—	Outer zone narrow
5	88	+	
	88	+	
	90	—	
	88	—	
	86	—	
6	88	—	
	78	—	
	78	—	
7	82	—	
	80	—	
	76	—	
8	88	—	
	84	—	
	82	—	
Mean of 26 measurements	86°	—	

Mean Composition: 77% Forsterite.

Range in Composition: 97% to 55% Forsterite.

## OLIVINE IN LYTTTELTON BASALTS AND OLIVINE-ANDESITES.

Rock Number.	2V.	Sign.	Remarks.
9	80°	—	
	86	—	
10	85	—	$\gamma-\alpha = 0.035$ (measured on a second grain)
11	86	+	
	87	+	
	89	+	
	89	+	
	90	—	
12	70	—	
	70	—	
	72	—	
Mean of 11 measurements	84	—	

Mean Composition: 72% Forsterite.

Range in Composition: 97% to 42% Forsterite.

OLIVINE IN DUNEDIN BASALTS.

Rock Number.	2V.	Sign.
13	82°	—
	90	—
14	86	—
16	80	—
	84	—
20	88	—
	88	+
21	80	—
	82	—
22	84	—
	86	+
23	84	+
	88	+
Mean of 13 measurements	87	—

Mean Composition: 79% Forsterite.

Range in Composition: 100% to 63% Forsterite.

OLIVINE IN DUNEDIN BASANITE, TRACHYBASALTS AND TRACHYANDESITES.

Rock Number.	2V.	Sign.	Remarks.
24	76°	—	} Basanite
	86	—	
	90	—	
25	76	—	} Trachybasalt
27	60	—	
	66	—	
31	89	—	} Trachyandesites
Mean of 7 measurements	78	—	

Mean Composition: 59% Forsterite.

Range of Composition: 87% to 24% Forsterite.

OLIVINE IN DUNEDIN KAIWEKITES AND PHONOLITES.

Rock Number.	2V.	Sign.	Remarks.
33	65°	—	} $\gamma - \alpha = 0.047$ for a second crystal Kaiwekites
34	82	—	
35	83	—	
36	90	—	
	88	+	} Phonolites
37	88	+	
38	89	—	

## DISCUSSION.

Barth (1931) found that the optic axial angle  $2V$  in phenocrystic pyroxene in Pacific basalts was uniformly about  $58^\circ$ , the range  $54^\circ$ – $60^\circ$  being exceeded only in the case of an olivinic sub-basalt from the Marquesas ( $51^\circ$ ). In zoned pyroxenes the consistently small optic axial angles and higher refringence of the outer zones indicated that with advancing crystallisation the pyroxene tended to become richer in iron but poorer in lime. The groundmass pyroxene is more variable. In the majority of the sub-basalts the optic axial angles varied between the above limits, but in the minority they were nearer  $40^\circ$  and in one case as low as  $20^\circ$ , indicating the presence of pigeonitic pyroxene [defined as possessing  $2V < 50^\circ$  (Barth, 1931a) or  $< 45^\circ$  (Kuno, 1936)]. In one sub-basalt from the Marquesas and in an oceanite associated therewith, pyroxenes with  $2V = 80^\circ$  and  $75^\circ$  respectively were noted (suggesting the presence of either alkaline or orthorhombic pyroxene, though Barth does not draw either inference). In the saturated basalts, half of the groundmass pyroxenes have  $2V = 40^\circ$ – $50^\circ$  and the remainder  $2V = 10^\circ$ – $40^\circ$ . In the plateau basalts of Greenland, Iceland, the Faroes, Spitzbergen and the Deccan, the pyroxenes are almost uniformly pigeonite (Barth, 1936, and authors cited therein).

Tsuboi (1832) showed that in the saturated andesites of Japan the phenocrysts are normally hypersthene and augite, and the groundmass-pyroxene pigeonite. Kuno noted that pigeonitic phenocrysts occur rarely, and that augite and hypersthene may be present together in the groundmass. Tsuboi concluded that the first two types of pyroxene are only partially miscible in the intratelluric stage of slow cooling, though completely miscible in the effusive stage.

Kuno, extending Barth's evidence for increasing concentration of  $\text{FeSiO}_3$  in the magma during the crystallisation of the pyroxene, held that the course of crystallisation depended on the total composition of the normative pyroxene in the magma. If it lay on the magnesian side of a line joining  $\text{CaSiO}_3$  ( $=\text{Wo}$ ) to the point  $\text{En}_{52}\text{Fs}_{48}$  on a triangular diagram, intratelluric crystallisation commenced with the formation of diopside and/or hypersthene (according to the composition in regard to Tsuboi's "two-pyroxene boundary"). (See Fig. 6.) This might be followed by formation of pigeonite (zonally about the diopside, or intergrown with or making over the hypersthene), when by increasing concentration of  $\text{FeSiO}_3$  the composition of the magmatic pyroxene had entered the pigeonite-field. In the quickly cooling effusive stage the groundmass pyroxene might be diopside and hypersthene, but was more usually pigeonite. Should, however, the normative pyroxene in the initial magma show a pigeonitic composition, that type of pyroxene will crystallise directly either on rapid or slow cooling. These conclusions, it is held, are in general accord with Bowen and Schairer's (1935) deductions from their experimental work.

Kennedy (1933) drew a sharp distinction between the nature of pyroxene in olivine-basalts and tholeiites. The former, he held, gave rise to quartzless alkaline differentiates, trachyandesite, trachyte and phonolite, and possessed only diopsidic pyroxene- [exceptions to this had been described by Barth (1931)]; the tholeiites gave rise to andesites, dacites, and rhyolites, and contained chiefly pigeonitic pyroxenes. "In undersaturated basalts (such as those studied by Barth) it is shown that the profuse early crystallisation of olivine so enriches the residual liquid in lime relatively to magnesia and iron that when the pyroxene begins to crystallise it does so in a diopsidic variety, whereas in the over-saturated basalts or basic andesites (similar to the types studied by Tsuboi) no olivine or only a little olivine separates out, and early crystallisation of pyroxene will take place with the formation of a relatively lime-poor pigeonitic variety" (Tyrrell, 1937). The last author (*loc. cit.*) has described the pyroxene phenocrysts in an Antarctic limburgite as "pale brown almost colourless or even faint green diopside with  $2V = 60^\circ$ , whereas the groundmass pyroxene together with the narrow margins of the phenocrysts consist of purple titanaugite with  $2V$  about  $15^\circ$ – $20^\circ$ ."

Barth's (1931) studies of optic axial angles of olivines in Pacific lavas indicate a moderate variation in composition, with a tendency to become richer in iron with decreasing basicity of the enclosing rock. In the sub-basalts it rarely exceeds the limits, forsterite 78% to 87%, and averages 84%. The average composition of olivines in pacificites and saturated basalts (and also the only olivine-phonolite noted) is 80% forsterite.

With this summary we may compare the results of the present investigation.

#### CONCLUSIONS.

In Dunedin basalts pyroxene usually occurs in two generations. The large phenocrysts are always diopsidic titan-augite. When zoned structure is shown the outer zones sometimes appear to be richer in clinoenstatite than the core. While this agrees with Barth's observations it does not accord with the experimental work of Bowen (1928, pp. 49–52) on the system diopside-forsterite-silica. In the groundmass diopsidic titanaugite may be associated with orthorhombic pyroxene, and in a few instances the latter only was observed. In one example hypersthene forms small phenocrysts (No. 21). The appearance of augite and hypersthene as separate mutually associated phases in Dunedin basalts, suggests that the temperature of crystallisation of the groundmass may be lower than is normal in basaltic lava; unusual richness in volatile constituents is certainly indicated by plentiful deuteric siderite in many of the Dunedin rocks. Pigeonite as defined by Kuno ( $2V < 45^\circ$ ) occurs but rarely, notably

as phenocrysts in No. 17 (normative pyroxene =  $\text{Wo}_{87}\text{En}_{38}\text{Fs}_{24}$ ). Transitional types of pyroxene which would be classed as pigeonite ( $2V < 50^\circ$ ) by Barth occur in No. 15 as phenocrysts in a groundmass of normal augite (normative pyroxene =  $\text{Wo}_{43}\text{En}_{35}\text{Fs}_{22}$ ), and both as phenocrysts and in the groundmass of No. 13 (normative pyroxene =  $\text{Wo}_{36}\text{En}_{33}\text{Fs}_{31}$ ).

The usual pyroxenes recorded in the more alkaline rocks of the Dunedin district (trachyandseities, kaiwekites and phonolites) are diopsidic augite, aegirine-augite and aegirine. In one section of trachybasalt (No. 25) orthorhombic pyroxene is plentiful. In No. 26, decrease in axial angle from the central zones outward in crystals of titan-augite was noted.

In the basalts of Auckland and the Late Tertiary basalts of Banks' Peninsula, diopsidic augite is almost always the only pyroxene present. Orthorhombic pyroxene was recorded in one rock from Banks' Peninsula (No. 9) and in one from Auckland (No. 7); in both cases it is associated with normal augite which in No. 7 is also accompanied by augite approaching pigeonite in composition. When phenocrysts show zonary structure the clinoenstatite content usually increases from within the crystal outwards, but the reverse condition was noted in two rocks (Nos. 6 and 11).

Olivine is more plentiful in the basalts of Auckland than in most Banks' Peninsula or Dunedin basalts. The mean compositions for olivines from the three localities, as deduced from the axial angle, are: Auckland, 77% forsterite; Banks' Peninsula, 72% forsterite; Dunedin, 79% forsterite. The relatively low figure for the Lyttelton mineral is due to inclusion of three measurements made on iron-rich olivines (forsterite, 45%) in an olivine-andesite.

In the basanites, trachybasalts and trachyandesites of Dunedin the iron-content of the olivine is generally higher than in basaltic olivine, the percentage of forsterite in one instance being as low as 24% (No. 27). In one of the three kaiwekites examined pale-yellow iron-rich olivine (24-32% forsterite) was also noted. In the two remaining kaiwekites (Nos. 34 and 35) the forsterite content of the olivine is about 70%.

The olivine of three typical olivine-phonolites from Dunedin is consistently magnesian (forsterite 85-90%). It occurs as xenocrystic clusters rimmed with aegirine. Small xenoliths of olivine basalt are common in such rocks.

The writers wish to record their thanks to Professors J. A. Bartrum and R. Speight for loan of material from Auckland and Lyttelton respectively; and to Dr. P. Marshall for the original material from Otago North Head.

## APPENDIX.

The following hitherto unpublished analyses of rocks containing minerals described in the foregoing were made by Mr. F. T. Seelye, F.I.C., to whom and to the Directors of the Dominion Laboratory and the Geological Survey the authors' thanks are due.

Rock No.	23	26	30	31	33
SiO <sub>2</sub> ..	45.77	52.37	57.88	56.22	58.53
Al <sub>2</sub> O <sub>3</sub> ..	12.98	18.49	18.07	18.56	16.17
Fe <sub>2</sub> O <sub>3</sub> ..	3.17	2.53	2.22	2.57	3.78
FeO ..	8.86	5.17	2.54	2.95	2.70
MgO ..	16.00	2.34	0.83	1.03	1.28
CaO ..	9.67	5.25	3.94	3.51	3.44
Na <sub>2</sub> O ..	2.33	5.47	5.77	7.20	5.66
K <sub>2</sub> O ..	0.83	3.20	3.94	4.59	4.51
K <sub>2</sub> O+ ..	0.98	1.06	1.02	0.86	1.24
H <sub>2</sub> O— ..	0.40	1.59	0.77	0.78	0.85
CO <sub>2</sub> ..	0.10	0.03	0.43	0.10	0.49
TiO <sub>2</sub> ..	2.05	1.27	1.55	0.87	0.80
ZnO ..	Nt. fd.	Nt. fd.	0.06	Nt. fd.	0.03
P <sub>2</sub> O <sub>5</sub> ..	0.40	0.46	0.56	0.36	0.26
S ..	0.02	0.05	0.02	Tr.	0.03
Cl ..	0.01	0.09	Tr.	0.17	0.03
Cr <sub>2</sub> O <sub>3</sub> ..	0.07	Nt. fd.	Nt. fd.	Nt. fd.	Nt. fd.
V <sub>2</sub> O <sub>5</sub> ..	0.03	—	—	—	—
MnO ..	0.20	0.23	0.11	0.18	0.16
NiO ..	0.04	0.02	Tr.	Nt. fd.	Tr?
BaO ..	0.02	0.09	0.10	0.11	0.12
SrO ..	0.04	0.02	0.03	Tr.	0.01
O for Cl ..	99.97	99.73	99.84	100.06	100.19
		.02		.04	.01
	99.97	99.71	99.84	100.02	100.18

23. Olivine Dolerite (Slide No. 42), Farley Street, Kaikorai, Dunedin.

26. Trachybasalt (Slide No. 44), Nevis Street, Kaikorai, Dunedin.

30. Trachyandesite (Slide No. 401), at depth of 250ft. in bore 50 yards W. Dunedin Railway Station.

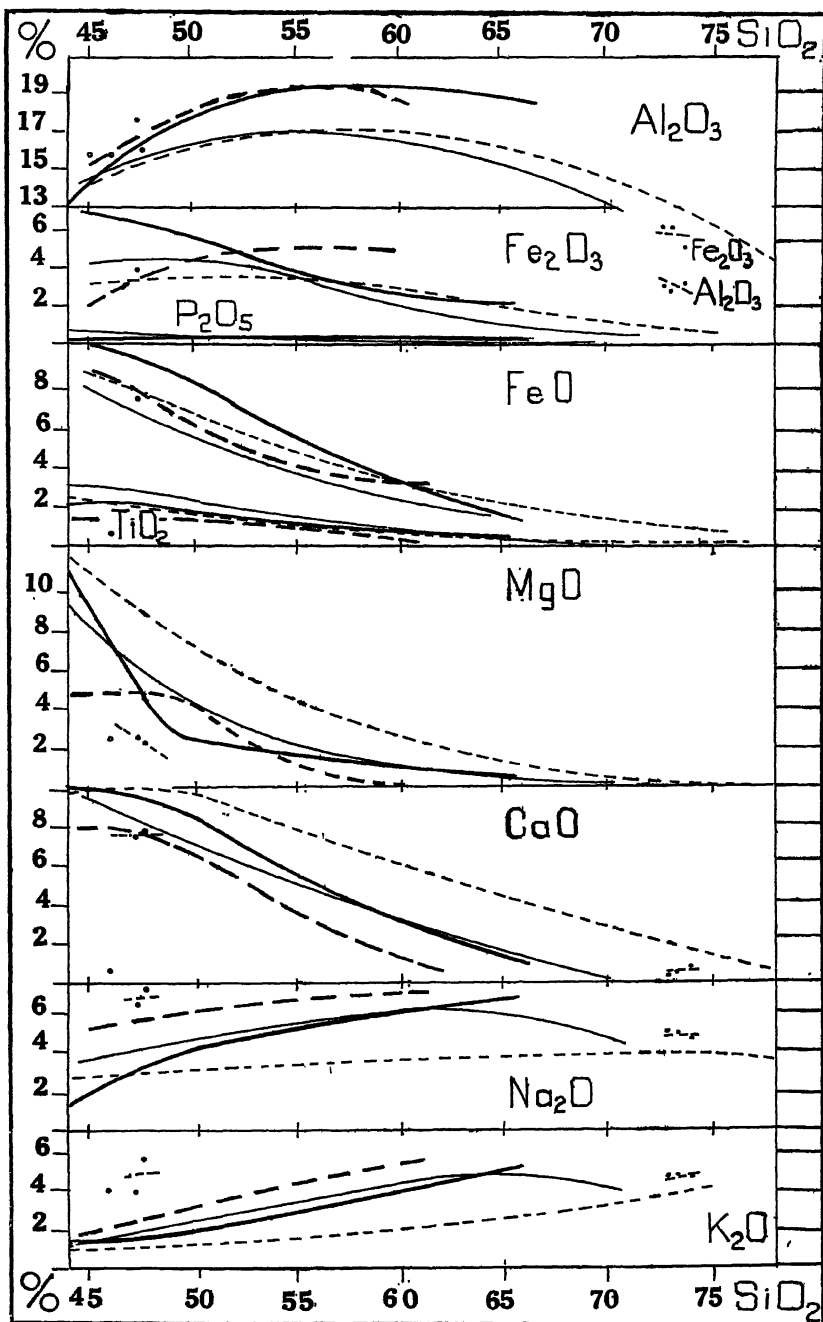
31. Phonolitic Trachyandesite (Slide No. 70), Robin Hood Quarry, Otago Boys' High School, Dunedin.

33. Kaiwekite (Slide No. 680), Te Whakareka-iwi, Otago Peninsula.

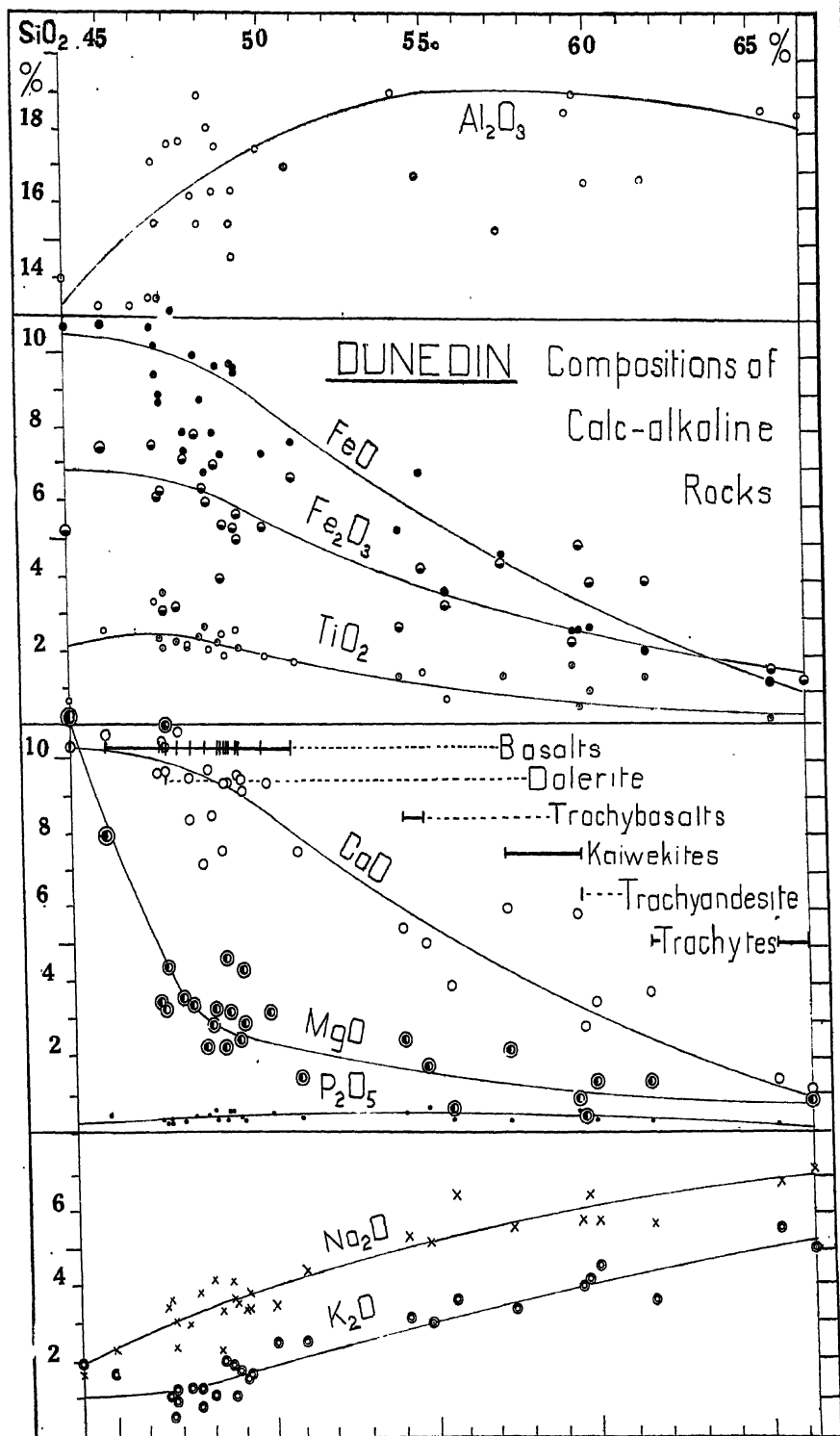
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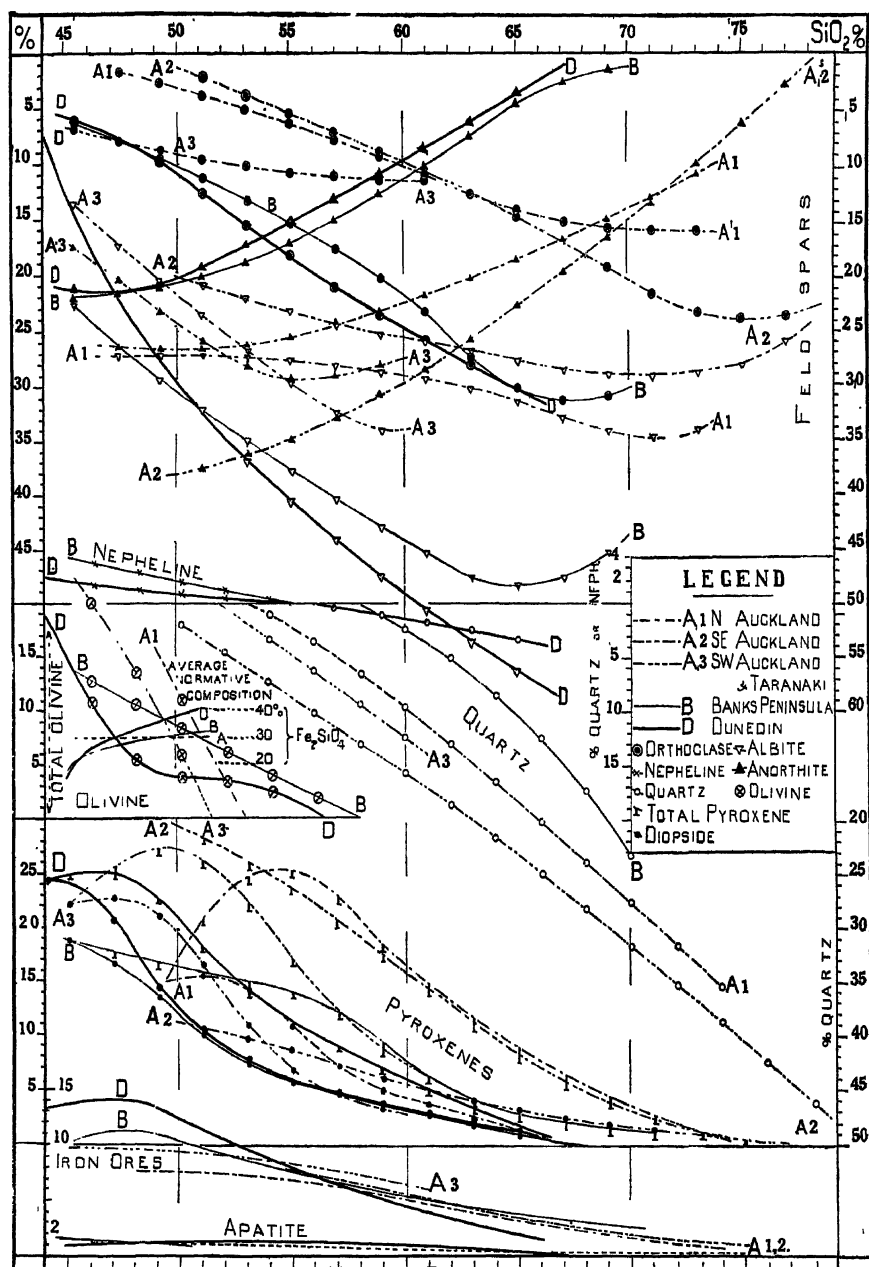


FIG. 4.—Norm-variation diagram for New Zealand calc-alkaline Cainozoic Volcanic Rocks.



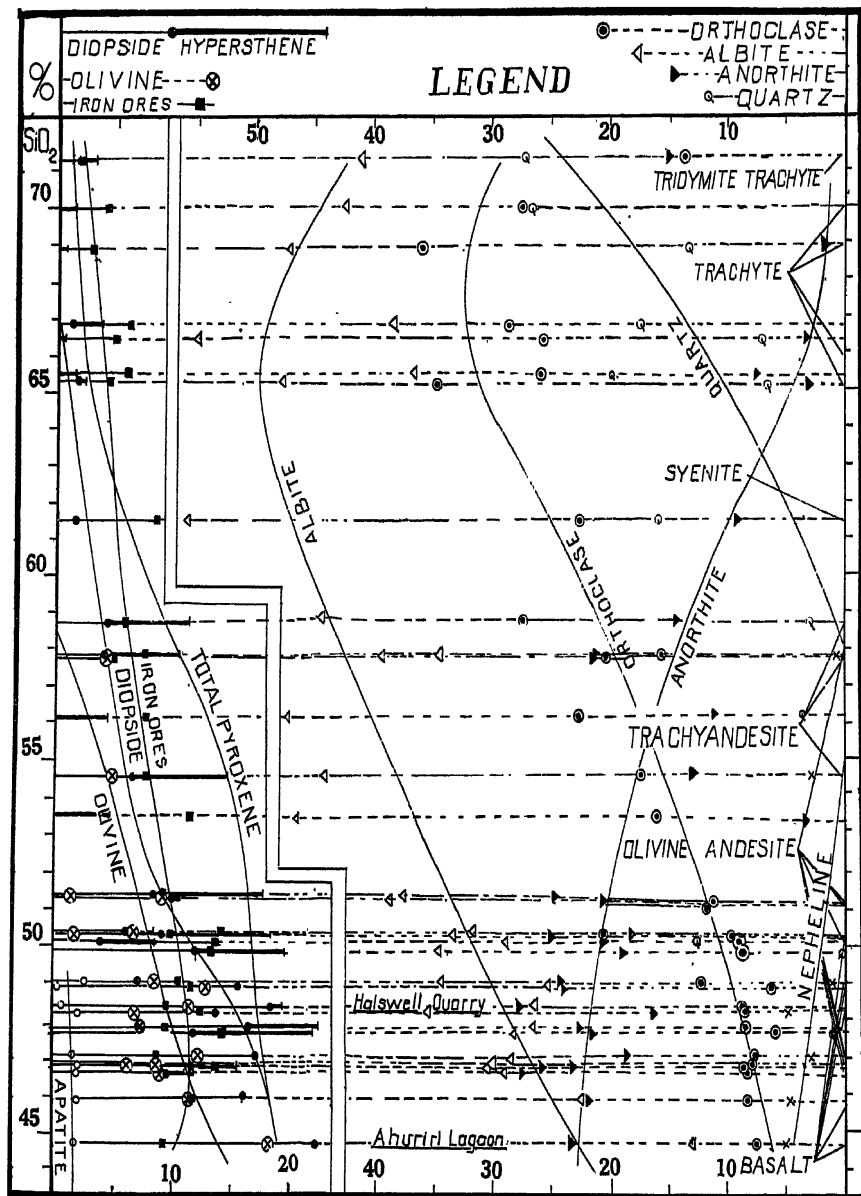


FIGURE 5.

To follow plate 4.



## The Bob's Cove Tertiary Beds and the Moonlight Thrust-Fault.

By C. OSBORNE HUTTON, M.Sc., Ph.D., F.G.S.,  
Petrologist, New Zealand Geological Survey.

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### INTRODUCTION.

SINCE 1864, when T. R. Hacket (1864) announced the discovery of limestone near Bob's Cove, on the shores of Lake Wakatipu, western Otago, much attention has been paid to this formation of Tertiary rocks, the Bob's Cove Beds. Hector (1870), Hutton (1872, 1875), Blair (1876), Cox (1879), McKay (1881, 1894), Park (1909) and Benson (1934, 1935) have all either examined them in the field or discussed their relations with the metamorphic rocks or with other Tertiary formations. Both McKay and Park made careful field examinations, but the latter writer alone appears to have realised that profound involvement of these beds within the schists had occurred. Park (*loc. cit.*, p. 66) established the following sequence for the Bob's Cove Beds:

- (a) Sandstone and conglomerates, passing downwards into bands of impure limestone.
- (b) Pure limestone.
- (c) Sandstone, marly and clayey.
- (d) Marly clays.
- (e) Calcareous breccia-conglomerates.

### OCCURRENCE OF THE TERTIARY ROCKS.

The Tertiary deposits occur on a low promontory along the shores of Lake Wakatipu, between Bob's Cove and Twelve Mile Creek (Few Creek), forming a small ice-shorn outlier about 250–300 acres in extent. Extending from the edge of Lake Wakatipu, for approximately 22 miles in a direction slightly east of north, is a narrow strip of the Tertiary sediments, never more than 150 feet thick, which have been caught in and thrust under the schists, by, it is believed, an easterly directed overfold (figs. 1 and 2).

## THE SEDIMENTS BETWEEN BOB'S COVE AND TWELVE MILE CREEK.

The Bob's Cove Beds dip steeply and have been very strongly warped so that the outcrop is S-shaped (fig. 3). The beds abut against the north shore of Lake Wakatipu and for a distance of about 15 chains in a northerly direction they strike at approximately  $17-20^{\circ}$  east of north and dip west at  $55^{\circ}$ . The beds then swing round to strike at  $255-260^{\circ}$  and dip to the south at  $50^{\circ}$ , until a point just south of Trig. station E is reached, when they again swing round to strike at  $11-12^{\circ}$  west of north and dip west at  $50-55^{\circ}$ . About six or seven chains north of the Trig. station, the beds end abruptly in a steep escarpment some 300 feet high. The writer believes with Park that these beds have been involved and overturned in an easterly thrust overfold, the interpretation of which will be considered later; therefore the apparently uppermost beds are really the oldest. The Tertiary sequence in order of decreasing age has been determined as follows:

Sandstone with bars of heavy conglomerate; about 300 feet thick (apparently highest, but actually the inverted basal bed of the Tertiary sequence).

Pebbly Limestone with numerous small fragments of schist; about 30 feet thick.

Limestone; about 65-70 feet thick.

Very Gritty Limestone; about 15-25 feet thick

Sandstone; about 300 feet.

Silty Sandstone; about 200 feet.

Siltstone (apparently lowest, but actually the youngest bed of the Tertiary sequence); at least 530 feet remain after overfolding and erosion.

The basal member<sup>1</sup> of the Tertiary Series, consisting of yellowish sandstone with bars of both heavy and fine conglomerates, adjoins the underlying schists with strong angular unconformity. The sandstone is sometimes very calcareous and may grade into a gritty limestone with increase of lime or into a fine conglomerate with increase in the amount of quartz or schist pebbles. A thin section of an average specimen contains much quartz, an important amount of calcite, with rare feldspar, clinozoisite, iron-ores, chlorite, muscovite, glauconite and foraminifera; in some sections fine fragments of schist were noted. Bars of conglomerate, 3-4 feet in thickness, consist of well cemented pebbles of various types of schists, up to 6 inches in diameter; fragments of a large *Ostrea* are sometimes abundant. From this bed McKay (1881) obtained species which he identified as *Crassatella ampla* Zittel and *Natica solida* Sowerby.

With apparent conformity these beds pass into the Pebbly Limestone, which is estimated to be at least 30 feet thick; it forms a steep dip slope facing west and south. This sediment is a fine compact greyish rock containing numerous pebbles of green schist and frequently large grains of pyrite, now in part replaced by limonite-pseudomorphs. Narrow pebbly and shelly bands are common, while

1. The basal member of the Series is now the topmost bed owing to overturning.

silty bands were also noted. Microscopically the rock (No. 3487)<sup>1</sup> is composed of plentiful calcite and numerous organic remains including algae and foraminifera; glauconite, quartz, feldspar and schist fragments are also present. From this horizon the following fossils were collected<sup>2</sup>:

Indeterminate coral remains.

*Retepora* sp.

*Venericardia* aff. *ponderosa* Suter.

*Cirsotrema* sp.

*Balanus* sp.

} From silty bands.

The Pebbly Limestone is followed conformably by the next bed, the Limestone. The outcrop, about 65–70 feet thick, forming the ridge of the crest of the outlier, is much shattered and broken, but exhibits very fine fluting and solution channels. Where it abuts against the lake it has been worn smooth by wave action and just at the water's edge contains many well-developed potholes, usually filled with numerous rounded pebbles. It is a fine grey, close-textured rock (No. 3450) containing in addition to predominant calcite, fragments of schist, quartz, feldspar, chlorite, muscovite, pyrite, glauconite and abundant organic remains. An analysis of this rock made by the writer is as follows:—

SiO <sub>2</sub> and insol.	..	..	1.40
Al <sub>2</sub> O <sub>3</sub>	..	..	1.65
Fe <sub>2</sub> O <sub>3</sub>	..	..	0.70
CaO	..	..	49.00
MgO	..	..	2.02
(Na,K) <sub>2</sub> O	..	..	0.03
CO <sub>2</sub>	..	..	44.50
S	..	..	str. tr.
Organic and H <sub>2</sub> O	..	..	0.66

99.96

Fossils occur very sparingly, but unfortunately none could be collected.

At the edge of the lake the Limestone appears to pass imperceptibly into the next bed, the Very Gritty Limestone, or the "Greensandstone" of McKay, which is here 20 feet thick. On being traced northwards, however, this bed appears to become somewhat thinner and more gritty, when the passage from the limestone to this bed is much more sharply defined. North of the Trig. station, however, the bed thickens once more to about 25 feet. In a specimen taken at the shore of the lake, calcite is dominant, though glauconite and quartz are abundant; in the more gritty parts, however, at a point 15 chains north of the lake shore, fragments of schist and

<sup>1</sup> Rock section numbers refer to the collection at the University of Otago.

<sup>2</sup> The writer is very much indebted to Dr. C. R. Laws, of Auckland, for determining the Mollusca.

grains of calcite are present in about equal amounts. On weathering this rock gives rise to a yellowish-brown sand, the colour being due to the alteration of the chlorite in the component pebbles of green schist. Near the lake-shore joint-planes are numerous, one of which, striking at  $140^{\circ}$  with a south-westerly dip of  $50^{\circ}$ , is particularly well marked. The bed may be quite fossiliferous, sparsely so, however, in the more calcareous parts. The following types have been collected by the writer:

*Odontocyathus* aff. *japonicus* Yabe and Eguchi.

? *Eupatagus* sp.

? *Waiparia* sp.

*Ostrea* sp.

*Lentipecten* sp. [probably *L. hochstetteri* (Zittel)]

? *Kuia* sp.

*Baryspira* sp.

*Xenophora prognata* (Finlay).

In the University of Otago geological museum there is a *Hemipatagus* sp. which appears to have come from this horizon, but the collector is unknown. In addition to these fossils, Park (1918) collected the following "from the sandstone below the limestone," a horizon presumably near to this bed; the modern nomenclature is given in brackets:

*Pecten huttoni* Park. [*Lentipecten hochstetteri* (Zittel).]

*Cucullaea alta* Sowerby. [This species has recently been dropped from New Zealand records, as it is a South American species.]

*Limopsis zitteli* Iher.

*Cardium huttoni* Iher. [Probably *Trachycardium* sp.]

*Venericardia purpurata* (Desh.). [See below.]

*Ostrea wuellerstorfi* Zittel. [*Gigantostrea wuellerstorfi* (Zittel).]

*Polinices ovatus* (Hutton).

*Ancilla hebera* Hutton. [*Baryspira* sp.]

*Dentalium mantelli* Zittel. [Probably *Fissidentalium* sp.]

NOTE: *Venericardia awamoensis* Harris may have been mistaken for *Venericardia purpurata* (Desh.), for the latter is a typically Recent species.

The coral *Odontocyathus* aff. *japonicus* Yabe and Eguchi is a sufficiently interesting type to warrant further notice, and was first described by Yabe and Eguchi (1932) from the Neogene of Japan. In the Otago University geological museum there is an unnamed, well-preserved coral from North Otago, and it appears to be identical

with the Bob's Cove specimen. In both specimens the septa are regular and 96 in number, the septa of the first cycle being most prominent. The North Otago type has the following dimensions:—

Diameter of calyx measured along septa of the first cycle	27	(32)
Diameter of calyx measured along septa of younger cycle ..	28	(26)
Greatest height to summit of exert primary septa .. ..	10	(22)
Least height in interval between two primary septa .. ..	9	(15)
Length of radial processes at base .. .. .	?	(?)
Length of radial processes at base of Bob's Cove specimen ..	10	

The figures in brackets are the dimensions of the type specimen described by Yabe and Eguchi from Japan. The ratio, diameter of calyx to least height in the New Zealand specimen is 3:1, while that in the Japanese type is 2:1. Hence the New Zealand specimen is a slightly flatter type, while the primary costae in contrast to the Japanese type are not nearly so pronounced. But its other features, such as number and arrangement of the septa and the presence of peculiar radiating spines or spiniform processes around the margin of the base clearly indicates its close relation to *Odontocyathus japonicus*.

The Very Gritty Limestone is followed conformably by the Sandstone, a yellow somewhat calcareous bed, about 300 feet thick, which in places may be slightly silty and sometimes rather glauconitic. The outcrop of this bed forms a steep cliff face from which thick slabs loosened by exfoliation have accumulated as talus. It contains many concretions, averaging about one foot in diameter, which, when split open, are seen to contain abundant fossil remains, unfortunately all unrecognisable. In a concretion from this bed McKay (1881, p. 145) discovered what he believed to be part of a skeleton of a *Plesiosaurus*-like reptile, but later (1894, p. 13) he considered that the vertebrate remains might be cetacean or reptilian. Professor W. B. Benham has recently examined the vertebrate material collected by McKay and has most kindly allowed the present writer to make use of his notes in this connection. Professor Benham states "that one tooth in longitudinal section is 2 cm. in length by 4 mm. in diameter with a narrow pulp cavity surrounded by black or dark brown dentine enclosed in thick enamel. The tooth is a long narrow cone, somewhat curved; there is no 'root.' The block also shows 3 or 4 other isolated fragments of similar teeth. One is a transverse section in which a pulp cavity is not evident; evidently near apex. Another is a longitudinal section with very narrow pulp-cavity near the base. The teeth probably belong to some 'modern Odontocete' (as opposed to ancient Odontocetes such as *Squalodon*, etc.) such as a Dolphin or Porpoise, but are too large for either of the existing species, but approach more nearly to *Cephalorhynchus hectori*, the 'Porpoise.' They are too slender and too short for *Globicephalus* ('Black Fish'), too long and too slender for *Tursiops*. They are much too big for any Teleost and lack the characteristic basal thickening of a shark's tooth."

Lying conformably on the Sandstone is the Silty Sandstone, a bed approximately 200 feet thick, with the junction between the two formations, except at the edge of the lake, obscured by the talus mentioned above. This bed appears to be the "Blue Sandy Marl" of McKay. As with the underlying sandstone, the bed usually forms a steep cliff, the present base of which is obscured by a talus of fragments loosened by exfoliation. The Sandstone is again calcareous, but more glauconitic and silty and contains more abundant fine fragments of schist than the underlying sandstone. Fossils are not abundant, but the following types have been collected by the writer:

*Lentipecten* sp. [Probably *L. hochstetteri* (Zittel).]

*Solecurtus* sp.

*Trachycardium* sp. [Cf. *T. waitakiensis* Suter].]

*Baryspira* sp.

*Fissidentalium solidum* (Hutton).

*Panope* sp.

? *Kuia* sp.

*Fucoids*.

This bed passes up into the uppermost bed, the Siltstone or "Marl" of Park. It is at least 530 feet thick and is inturbed against a highly irregular surface of brecciated schist, but at the lake-edge it is in contact with the breccia of the zone of the thrust-fault. It is a fine-grained, homogeneous sediment, sometimes rather gritty due to admixture with fragments of schist. Park (1909, p. 100) gives an analysis of this sediment:

CaCO <sub>3</sub>	..	..	..	..	34.52
CaO (otherwise combined)	..	..	..	..	2.39
(Al,Fe) <sub>2</sub> O <sub>3</sub>	..	..	..	..	6.50
MgO	..	..	..	..	0.72
SiO <sub>2</sub> and insol.	..	..	..	..	51.60
Alkalis and loss	..	..	..	..	2.51
H <sub>2</sub> O	..	..	..	..	1.76

100.00

Analyst: G. M. Thomson, 1909.

This Siltstone possibly had a much greater thickness than is seen now, for much of the sediment has been sheared out by tremendous thrusting, and, further, it must have been somewhat reduced by erosion before thrusting took place. Fossils are not abundant and are confined almost entirely to the lowermost horizon, just above the Silty Sandstone. The following types have been collected by the writer:

Indeterminate coral remains.

*Cucullaea worthingtoni* Hutton.

? *Austrofusius* sp.

*Trachycardium* sp.

In 1875 Hutton also collected fossils from the Bob's Cove Beds, but unfortunately did not state from what horizon they were obtained. The species reported by that worker are listed as follows:

*Dentalium giganteum* Sowerby. [*D. solidum* Hutton.]

*Voluta corrugata* Hutton.

*Panopaea plicata* Hutton.

*Panopaea worthingtoni* Hutton.

*Cucullaea ponderosa* Hutton.

*Cucullaea worthingtoni* Hutton.

*Cucullaea alta* Sowerby.

*Cucullaea attenuata* Hutton.

*Waldhemia lenticularis* Desh.

With regard to *V. corrugata* Hutton, Marwick (1926, p. 299) remarks that "until some topotypes have been secured, however, the best course is to ignore this species," a view later upheld by Finlay (1927, p. 513). Finlay (1926, p. 473) points out that the correct spelling of *Panopaea* is *Panope* and further he does not appear to recognise *P. plicata* Hutton as a type. Nevertheless Finlay and Marwick (1937, p. 36) point out that according to Sherborn *Panopea* appears to be the correct spelling. Finlay (1926, p. 448) notes that *Cucullaea worthingtoni* Hutton is identical with and has priority over *C. attenuata* Hutton. In the list of fossils above it is possible that Hutton's *Waldhemia lenticularis* Desh. is *Waiparia* sp.

Brief reference might be made here to the investigation of the heavy residues in some of the Bob's Cove sediments (Hutton and Turner, 1936). This work has shown that except for the interesting but rare occurrence of monazite, all the minerals identified are known to be present in the local metamorphic rocks.

#### THE ROCKS IN THE ZONE OF THE THRUST-FAULT.

The thrust-zone with its involved Tertiary sediments has an average strike of about 15° east of north and dips to the west at angles between 50–70°, while the character and the amount of the sediments varies considerably as they are traced northwards.

At the edge of Lake Wakatipu, the thrust zone is approximately 60 feet thick, with a strike about 3° west of north and a westerly dip of 54°. Here the involved material is a calcareous breccia composed of angular fragments of schist, abundant grains of quartz, feldspar and some foraminifera, cemented by calcium carbonate. On weathering, this rock has the appearance of broken concrete, for solution of the carbonate has left the schist fragments protruding from the matrix. Immediately to the west of this zone is the Siltstone described earlier, but 50 yards north from the lake shore this Siltstone gives way to a mass of brecciated schist (see fig. 3); to the east of this zone of thrusting for a distance of about 75 yards the schist is intensely brecciated and shattered. Continuing northwards the thrust-zone can be traced for a distance of about 600 yards, when it disappears under a thick covering of alluvium.

Just less than a mile from the edge of the lake, the zone reappears from beneath the alluvial covering, outcropping close to the right bank of Twelve Mile (Few) Creek; the zone of involvement runs parallel with it for some 400 yards, then crossing the creek ascends a steep gully to a low saddle, 1,875 feet high, situated between Lake Dispute and Twelve Mile Creek. The rocks exposed on the bank of this creek strike at  $14-15^{\circ}$  east of north and the dip is to the west at  $55^{\circ}$ ; the rock walls are very shattered, particularly those to the east. The sequence determined here is as follows:

A narrow black band of pulverised schist which is followed by a coarse siltstone (about six feet thick) containing grains of glauconite and remains of dicotyledonous leaves; this bed passes up into a fine conglomerate (about eight feet thick) containing fragments of a large *Ostrea*.

At the saddle the sequence has changed, and here a green gritty limestone containing foraminifera passes up into a breccia with fragments of a large *Ostrea*. Continuing north, the zone clings to the top of the ridge and passes over a spur of Mount Hanley at an altitude of approximately 3,800 feet, at which point it intersects the Twelve Mile Thrust. It then rapidly descends a precipitous slope almost to the fans south of the west arm of Moke Lake and continues north across the Left Hand Branch of Moke Creek. After passing Mount Hanley the zone is narrow and consists chiefly of brecciated schist, together with a small amount of red siltstone at the outcrop in the gorge of the Left Hand Branch. From this creek the zone continues north over ridge and valley to Slip Creek, which it crosses at an altitude of about 2,100 feet. The zone is best observed on the north slope of a ravine at 2,800 feet, where the outcrop is about 75 feet wide, the strike being  $15^{\circ}$  east of north and the dip  $72^{\circ}$  to the west. The schist wall to the west is crumpled, but that to the east is intensely brecciated. In the nearby schists an easterly dip may be seen, but this reversal of dip is only local, for 100 yards to the east of the zone of involvement the normal westerly dip is resumed. The sequence at this point begins with:

A poorly feldspathic sandstone, interbedded with a very thin band of carbonaceous material. This is followed by a series of green and brown coloured breccias, the latter interstratified with a band of reddish siltstone containing finely divided haematite; the latter is probably the outcrop referred to by Cox (1882) as a haematite lode.

In the feldspathic sandstone the grains of quartz and feldspar show strong undulose extinction and granulation (Nos. 3430, 3436). The green breccia (No. 3429) is composed of angular fragments of green quartz-albite-chlorite-schist, up to 60 cms. in diameter, while the brown breccia (No. 3419), though similar, contains much calcite and is stained by the red siltstone. The composite fragments are usually deeply slickensided.

The zone continues north to cross Gill's Creek, on the north side of which the sequence is well exposed at an altitude of 3,000 feet. Here crumbling and contorted schist on the west is followed by a

zone of pulverised schist, three inches wide, 40 feet of fine calcareous grit (No. 3424) and 30 feet of fine breccia. This latter bed abuts against an eastern wall of strongly brecciated schist. The zone now crosses the ridge to descend to a tributary of Gill's Creek and after ascending a steep ridge to 3,650 feet, descends to cross Dead Horse Creek at 2,200 feet. At this locality a strike of 15–16° east of north and a dip of 65° to the west were recorded and in the zone itself occur 55 feet of gritty limestone divided in the middle by a band of sandstone, 2 feet wide. The limestone contains traces of dicotyledonous leaves, while a concretion was found which, when broken open, emitted a strong odour of hydrocarbons and contained indistinct carbonaceous remains. Rare fossils occurred in the sandstone, but only fragments of a large *Ostrea* were determinable.

The outcrop of the Tertiary rocks now ascends to 3,000 feet, crosses the upper reaches of Butcher's Creek and ascends the slopes of Craigallachie to an altitude of 3,600 feet, dropping rapidly to 1,800 feet to cross the Moonlight Creek. Here the outcrop, approximately 150 feet in width, is well exposed on the south face of the Moonlight Gorge, where it is crossed by the Lake Luna-Moke Creek pack-track; the strike is 15° east of north and the dip to the west at 70–75°. The zone rock is a feldspathic sandstone containing a minor amount of chlorite, muscovite and epidote; the quartz and albite show strong undulose extinction and granulation. The sandstone contains abundant indeterminate casts, fucoids and rarely a *Glycymeris* sp. Towards the footwall the bed appears to become more indurated.

The zone crosses the river and ascends the slopes of Mount Gilbert to pass east of the summit and then descends to Stony Creek, which it crosses at 1,800 feet. Here the Tertiary rocks consist of rather feldspathic sandstone and some conglomerate, about 20 feet thick in all; once again the eastern wall is intensely shattered and in places slickensided. From the sandstone Park (1909, p. 63) has reported the following fossils: *Venus* sp., *Pinna* sp., *Ostrea* sp. (very large and thick like *O. wuellerstorfi* Zittel), *Turritella* sp., *Natica* sp., *Dentalium* sp. (like *D. mantelli* Zittel), undetermined coral remains and *Fucoid* stems.

From Stony Creek the involved beds rise to a point almost at the summit of the Silverhorn (Trig. N, Shotover S.D.) and at this point reach an altitude of 5300 feet, which according to Park (1909, p. 63) is the greatest elevation at which Tertiary rocks have been found in New Zealand. From this point the zone continues north, clinging to the ridge west of Skipper's Creek and then ascending towards Mount Aurum. At this point the zone consists of some sandstone and breccia, but the outcrop is not very distinct. Later deep snow prevented any further work north of Mount Aurum, but the writer hopes to be able to continue this investigation soon.

#### INTERPRETATION OF THE MOVEMENT INVOLVING THE TERTIARY STRATA.

Any hypothesis advanced to explain the mechanism of the movement that caused the involvement of the Tertiary strata must explain the following points:

(1) Only a narrow band of Tertiary strata has been involved from Twelve Mile Creek to Mount Aurum, a distance of about 23 miles, while a thick sequence has been wedged in along the shores of Lake Wakatipu between Bob's Cove and Twelve Mile Creek.

(2) The same movement that involved the thin strip must likewise have involved the whole series at Bob's Cove.

(3) The Siltstone, the youngest bed of the Bob's Cove Series, lies adjacent to the breccia of the thrust-zone at the very edge of the lake, but 50 yards north from this point the sediment abuts against a mass of finely brecciated schist.

(4) The strike of the thrust-plane from the edge of the lake to the point where it disappears under the alluvial covering is approximately  $3^{\circ}$  west of north, but the average strike from Twelve Mile Creek to Mount Aurum is  $15^{\circ}$  east of north. Therefore there is a marked displacement between the outcrop of the thrust-zone south of the alluvium and that north of this covering.

(5) The schist wall east of the thrust-fault is always very much more shattered than the western wall. Also breccias, when they occur, almost always form the footwall, and the pebbles composing the breccias are most commonly Chl. 2 and Chl. 3 sub-zone schists.

In considering the Tertiary beds along the lake shore it was shown that they had suffered a peculiar warping in the process of which, it is believed, the whole series has been overturned. The evidence for overturning is twofold: (a) The succession on stratigraphic grounds appears to be inverted, and (b) the position of the sole of movement east of the strip of Tertiary rocks indicates overturning.

Now consider point (a) above; it has been shown that the Bob's Cove Beds grade down<sup>1</sup> from sandstone with bars of heavy conglomerates through limestone, sandstone and silty sandstone to siltstone. Again the siltstone, where it abuts against the schist, does contain a small amount of fine fragments of schist, but there is no sign of a basal conglomerate that so frequently occurs at the bottom of such a sequence. Therefore if the sequence were merely tilted, it would appear that sedimentation must have commenced in deep water and continued throughout a long period with the sea gradually becoming more shallow until finally subaqueous sediments gave place to littoral or beach deposits. Hence the writer would suggest that the beds are not tilted, but, instead, that they are completely overturned, so that the present uppermost beds, the coarse sandstone and conglomerates, are really the basal beds. The suggestion that basal conglomerates may have existed between the siltstone and the thrust-zone but have been torn away by the thrusting may be raised, but it will be shown that though some destruction of the sediments must have occurred, overturning alone will explain all the facts. Should overturning not have taken place the actual surface of thrusting, that is the sole of the movement, should not be below the siltstone but between the bed of conglomerate and sandstone and the adjacent schists.

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1. "Down" is not used in the stratigraphic sense.

It has been pointed out in statement (5) above that the schist wall to the east is always intensely shattered or brecciated, while the rocks to the west are barely disturbed or at the most are crushed or pulverised along a narrow zone only. Now if the sequence at Bob's Cove is an inverted one, the same must apply to this narrow strip. The deformation would seem to have been brought about through regional compression by the overturning of the Tertiary covering beneath an easterly thrust overfold (fig. 4, diagram A-C). A continuation of pressure from the west would probably result in thrusting along a plane between the Tertiary strata and the lower schist wall, so that the wedge of Tertiary rocks would be driven upwards along this inclined plane with consequent tearing, brecciating and slickensiding of the metamorphic rocks adjacent to this plane (fig. 4, diagram D). If a movement such as that figured by Park (1909, p. 64, fig. 15) took place, by which the Tertiary covering was merely folded in and embraced by the schists, then some evidence of a double sequence would be expected, but this is not the case. Two suggestions may be put forward to account for the absence of a double sequence:

(a) It is possible that at least half the involved formation has been torn away and destroyed by thrusting.

(b) After a period of compression, culminating in intense deformation by folding and thrust-faulting has occurred, relaxation of horizontal pressure may have brought about gravitational sinking of the upthrust block down the thrust-plane (fig. 4, diagram E). This would cause a deep involvement of a wedge of the Tertiary sediments which would not exhibit a double sequence. It is not stretching the mechanics of crustal movement too far to assume such a reversal of movement, for Bucher (1933, p. 2) points out in law 2 that "in the process of crustal deformation, the direction of radial displacement is reversible." Subsequent peneplanation (fig. 4, diagram E, plane a-b) of this region would then remove all sign of the Tertiary covering on both sides of the outcrop of the thrust-plane. The writer favours the latter hypothesis, for there are numerous instances where the former occurrences of both upward and downward movement along a fault-plane has been demonstrated such as along the south-west boundary of the Kakanui and Horse Ranges where greywacke makes up the high-standing block while the lowlands are composed of schist (Cotton, 1917, p. 273); further Waghorn (1928, p. 26) believes that the Ruahine block in the North Island is now subsiding, the movement taking place along the ancient fault-lines.

Comparable examples of involvement with overturning along thrust-faults of covering beds by underlying formations are not uncommon, for Bucher (1933, pp. 162-169) mentions several cases from the Southern Rocky Mountain region, while Heritsch (1929) gives many instances from the homogeneous mobile belt of the Swiss Alps. Examples of involvement without overturning are common in New Zealand; in the Murchison district of New Zealand, Fyfe (1929) has described the occurrence of a strip of Tertiary rocks lying between two broadly arcuate faults among granites, but although a

cross-section shows the sediments to be lying vertically, Henderson (1937, p. 87) indicated that the Tertiary rocks dip steeply to the eastwards and suggested that the eastern block of granite has overridden these sediments. Further, Turner (1935, p. 330) has described a zone of mid-Tertiary sediments involved among sheared greywackes in the Eglinton Valley, but there is no evidence to show whether overturning has taken place.

The greater thickness of the strata at Bob's Cove than that in the zone of the thrust-fault requires consideration. With overfolding and thrusting such as has been described, the cross-section of the involved strip is most likely to be wedge-shaped, the Tertiary rocks becoming sheared out at depth. Now if a block of the crust enclosing this wedge is faulted down below the base-level between faults at right angles to the zone of the thrust-fault, it will be preserved from intensive erosion; but as the base-level is lowered and the more elevated region is worn away, the outcrop of the Tertiary beds in that block will become narrower. Eventually the down-faulted block will reveal a wide infolded mass in contrast to the narrow strip in the block on the upthrown side (see fig. 4, diagrams G, H and I).

This reasoning may be applied to the Bob's Cove area. The Bob's Cove Tertiary beds occur on a promontory separated from the main landmass by thick alluvium and the writer believes that beneath this alluvial covering there is concealed a fault (as was suggested by Benson, 1934, 1935), the Bob's Cove fault, running approximately east and west, from near the mouth of Twelve Mile Creek to Bob's Cove itself; the Bob's Cove beds are on the down-thrown side. Therefore these Tertiary beds represent the thick end of the wedge while the strip from Twelve Mile Creek to Mt. Aurum corresponds to the thin end of the wedge enclosed within the much-eroded and penneplained block. A fault such as is postulated above must necessarily have brought about a displacement of the outcrops of the thrust-plane to the north and to the south, and this is precisely what is observed when the outcrop of the thrust-fault is plotted on an arbitrary plane surface (fig. 4, diagram J). As the thrust-plane dips at angles between 55–80° to the west, eastward displacement of the outcrop in the downthrown block should occur; and since the throw of the cross-fault (Bob's Cove fault) must have been very great, if it is to account for the observed variation in thickness of the involved beds, the eastward displacement of the beds at Bob's Cove must be considerable. Actually, however, the displacement, though obvious, is in the opposite direction, that is, the block of the Bob's Cove beds shows a relative displacement to the west. Therefore it would appear that the gravitative sinking was accompanied by considerable lateral movement of the down-thrown block in an east to west direction thus more than compensating the west to east displacement resulting from the vertical component of the movement (fig. 4, diagrams I and K).

Further evidence in support of the presence of the suggested Bob's Cove fault is seen in the fact that it is parallel to the main structure lines blocking out the Wakatipu graben, these lines being,

according to Benson (1935, p. 15), really revivals of ancient shatter-belts. In this case the Bob's Cove fault is probably a post-peneplain revival of an ancient pre-peneplain line of dislocation.

Two rather striking points remain to be explained:

- (a) The remarkable warping of the Bob's Cove beds.
- (b) The overlap of the siltstones from a mass of brecciated schist on to the breccia in the thrust-zone itself.

In regard to the first point, it is probable that the involved sediments caught up by the advancing fold would not move eastwards with a perfectly straight front, but there would be a certain amount of buckling here and there. Consider the limestone band advancing eastwards in such a way that one point in the band advances eastwards more than another point 20-25 chains to the north; this would cause the shape of the outcrop of the involved wedge to conform more or less with that of the beds at Bob's Cove. The cause of such buckling may possibly be due to variations in thickness of the semi-plastic silty sediments which might have been squeezed laterally to some extent, thus presenting an uneven resistance to the schists moving from the west. As a result of this, sharp deflections of the competent beds of limestone, sandstone, conglomerate, etc., would probably take place. A continuation or inequality of the thrusting from the west might then shear through the wedge producing flaw-faulting along such planes as the Bob's Cove fault (see fig. 4, diagram F). The section between c and d in fig. 4, diagram F, therefore represents the Bob's Cove beds.

Now consider the second point; the block of schist lying between the siltstone and the zone of thrust-faulting near the shore of the lake may be regarded as a "horse" of the basement rock caught up and involved in the thrust.

Finally it must be admitted that comparison of the involved Tertiary beds at different vertical heights (e.g. on the Silverhorn at 5,300 feet and at the level of Stony Creek at 1,800 feet) fails to show any very great variation in thickness such as might be expected on the assumption that the involved strip is wedge-shaped. But it must be remembered that the depth of involvement must be very great, therefore, the wedge-shape need not be a markedly noticeable feature in a vertical section of about 3,500 feet. Further, the width of the outcrop widens northwards from the West Branch of Moke Creek and this is interpreted as due to (a) decreasing depth of involvement northwards or (b) the greater shearing out of the wedge towards the south.

#### THE AGE OF THE BOB'S COVE BEDS.

Unfortunately the fossils have been very poorly preserved and are commonly so distorted by shearing that specific determinations were in most cases impossible. Dr. C. R. Laws suggests that certain of the mollusca, especially *Xenophora prognata* (Finlay), *Cucullaea worthingtoni* Hutton, *Trachycardium* sp., *Venericardia ponderosa* Suter and *Solecirtus* (if it be allied to *S. bensoni*), indicate Ototaran

age. In the Otago University Geological Museum there is a single specimen of a well-preserved *Rhizothyris fortis* Thomson, labelled Skipper's, and this is a type confined solely to the Hutchinsonian Stage of the New Zealand Tertiary. Undoubtedly this fossil must have been carried down from the Tertiary strata either in Stony Creek or a tributary of Skipper's Creek. It must be pointed out that there is a marked absence in the Bob's Cove beds, excluding the doubtfully identified *Venericardia awamoensis* Harris, of typical Awamoan forms such as: *Lima colorata* Hutton, *Spissatella trailli* (Hutton), *Neilo awamoana* Finlay, *Tawera marshalli* Marwick and *Limopsis zelandica* Hutton. Therefore it would seem best to fix the upper limit of these beds as Hutchinsonian and the lower as Ototaran.

#### THE DATE OF THE INVOLVEMENT OF THE TERTIARY STRATA.

It has been shown that the Tertiary beds involved in the movement are at the latest Hutchinsonian (late Oligocene) in age and hence the thrust-faulting must be post-Hutchinsonian. It would not be possible to place an upper limit upon the date of the thrust-fault were it not for the fact that there is evidence that the district has since undergone a profound peneplanation affecting both Tertiary and older formations alike. The evidence is to be seen in the accordance of summit levels in the district through which the thrust-fault runs. Marshall (1918), Benson (1934, 1935) and Service (1934) have noted the occurrence of a late Tertiary peneplain in eastern coastal districts of Otago and also faulting movements occurring after the time of deposition of the Tertiary beds but before the peneplanation. It has been made clear by Benson that the peneplain recognised in the Wakatipu area is coeval with that in eastern Otago and further that writer (1934, 1935) considers that the peneplain in the Wakatipu area is merely an extension of the very extensive Fiordland peneplain. From evidence in eastern Otago it is only possible, at least at present, to restrict the age of the peneplain to somewhere between the Hutchinsonian and the Pliocene, so that the age of the Moonlight involvement, though it must antedate the peneplanation, can be placed only between the same limits.

The date of the involvement of the Tertiary rocks has been considered, but there is evidence pointing to the fact that an ancient zone of dislocation may have guided the course of the late Tertiary movement. It seems clear that at the time the Tertiary rocks were laid down pre-Tertiary erosion had laid bare a range of metamorphic rocks such as are now exposed, for the Tertiary rocks rest on poorly metamorphosed Te Anau rocks in the Eglinton Valley and on more metamorphosed schists in the Lake Wakatipu region. Dr. Benson has pointed out to the writer that the apposition of the Chl. 2 and Chl. 3 sub-zone rocks on the east side of the Late Tertiary Moonlight thrust-fault to the Chl. 4 rocks on the western side suggests that such formations were in close proximity prior to the deposition of the Cainozoic sediments; and further that the great overthrusting movements which occurred here in Late Tertiary time were in large measure a revival of dislocation along a plane of faulting that had been active in Pre-Tertiary times.

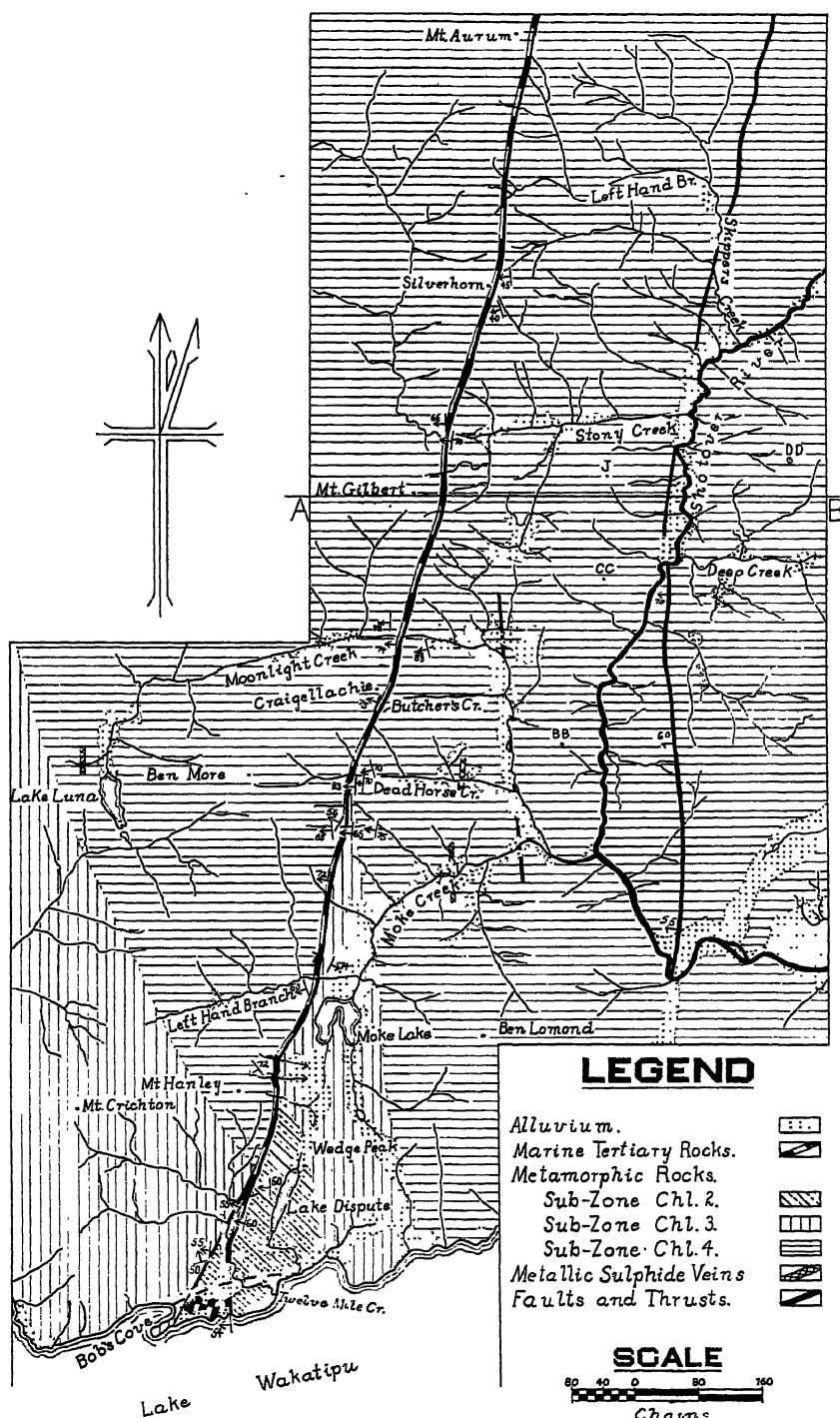
In conclusion, the writer wishes to thank sincerely Professor W. N. Benson and Dr. F. J. Turner for the assistance they have given him with the development of this paper. To Professor W. B. Benham acknowledgment is due for having allowed the writer to make use of his notes on the Bob's Cove "porpoise".

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# MOONLIGHT THRUST-FAULT LAKE WAKATIPU.

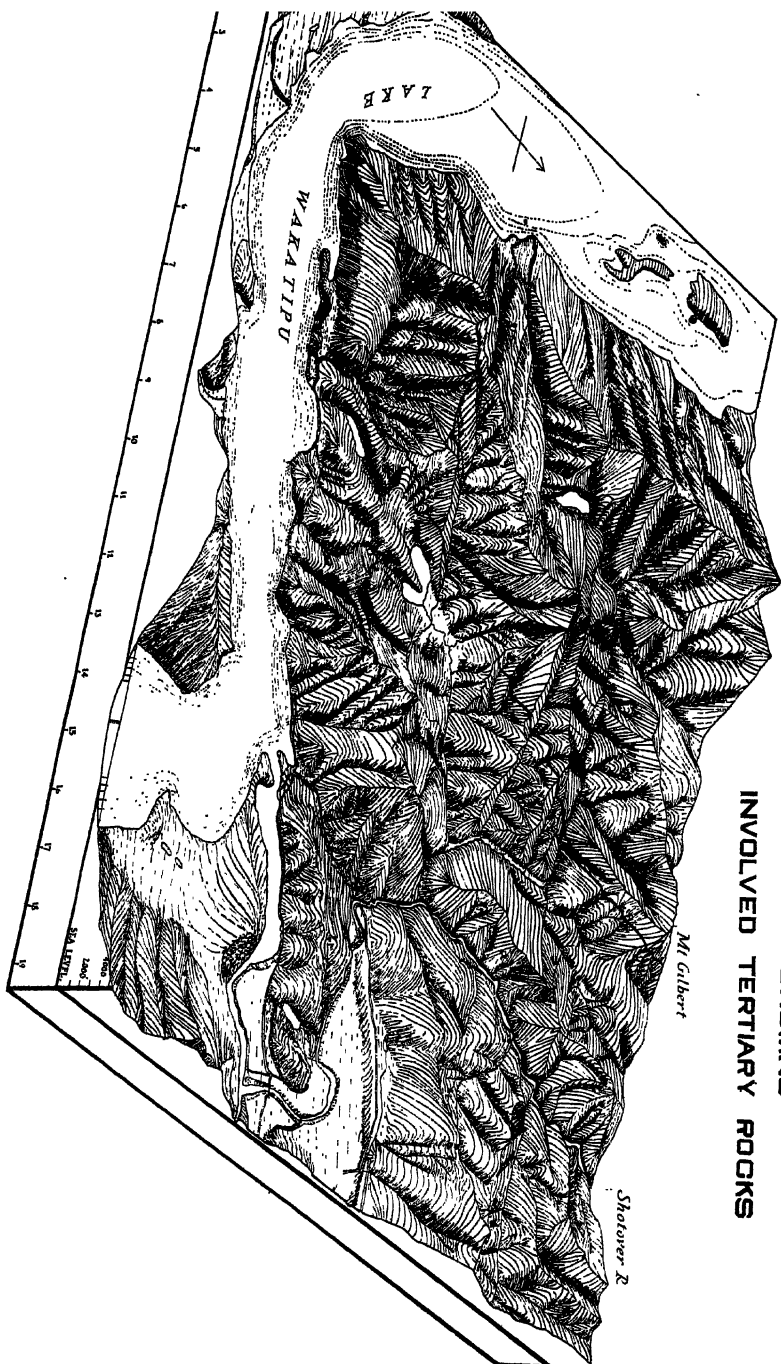






**BLOCK DIAGRAM OF EASTERN CENTRAL WAKATIPU**

**SHOWING  
INVOLVED TERTIARY ROCKS**





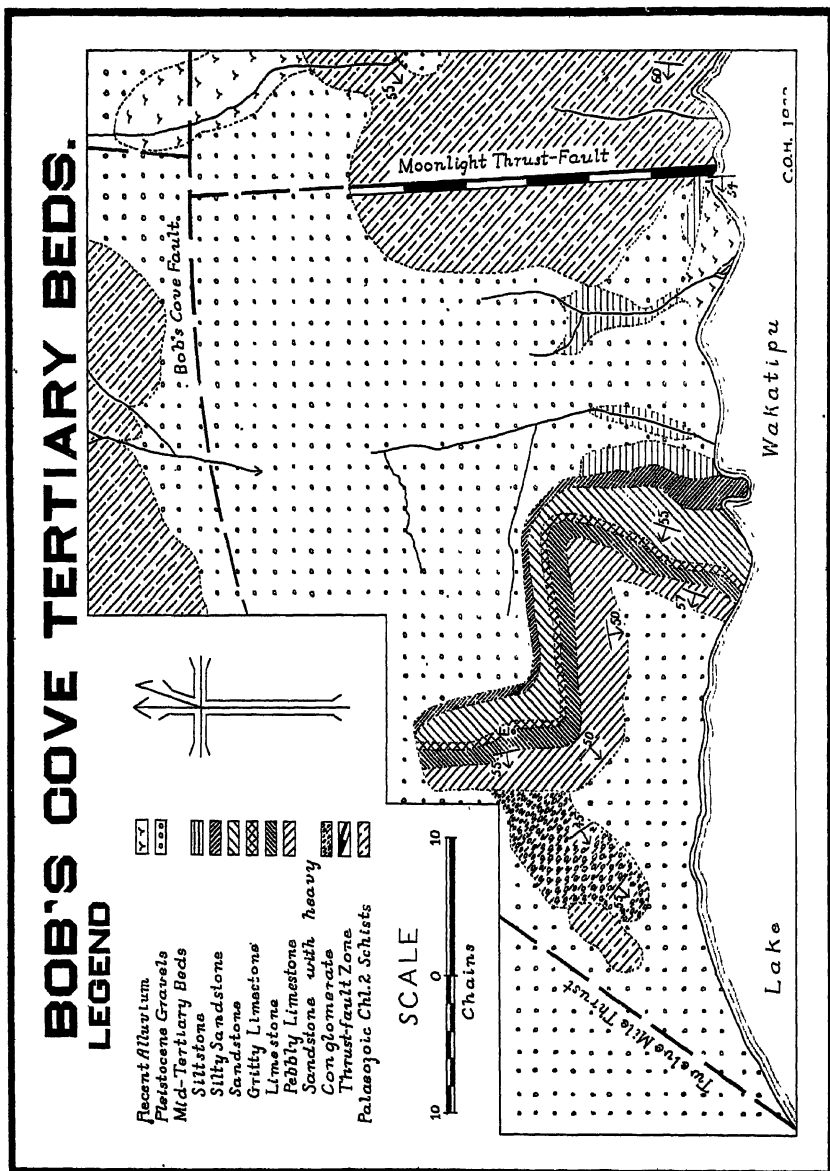


FIGURE 3.



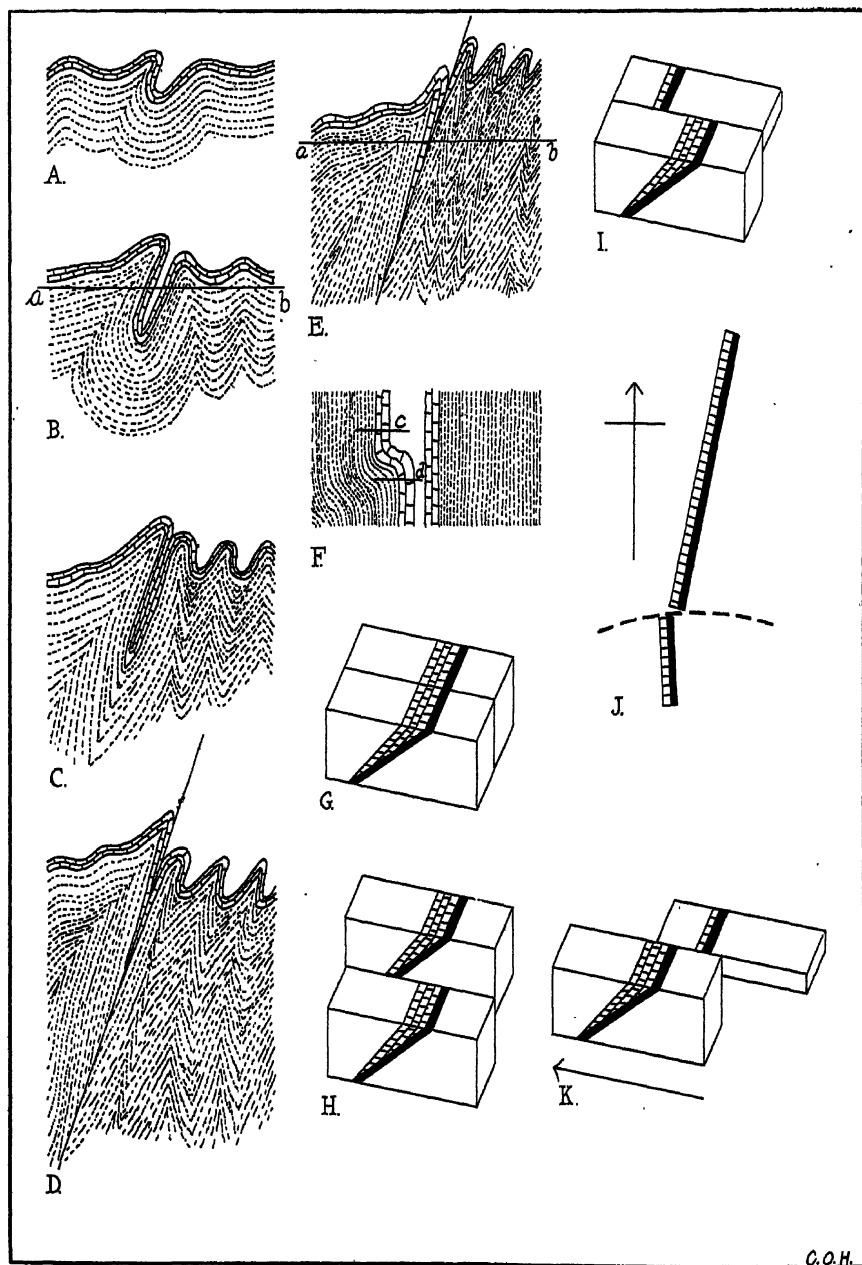


FIG. 4.—Diagrams to illustrate the mechanism of the involvement of the mid-Tertiary Bob's Cove rocks at Bob's Cove itself and along the line of the Moonlight thrust-plane,



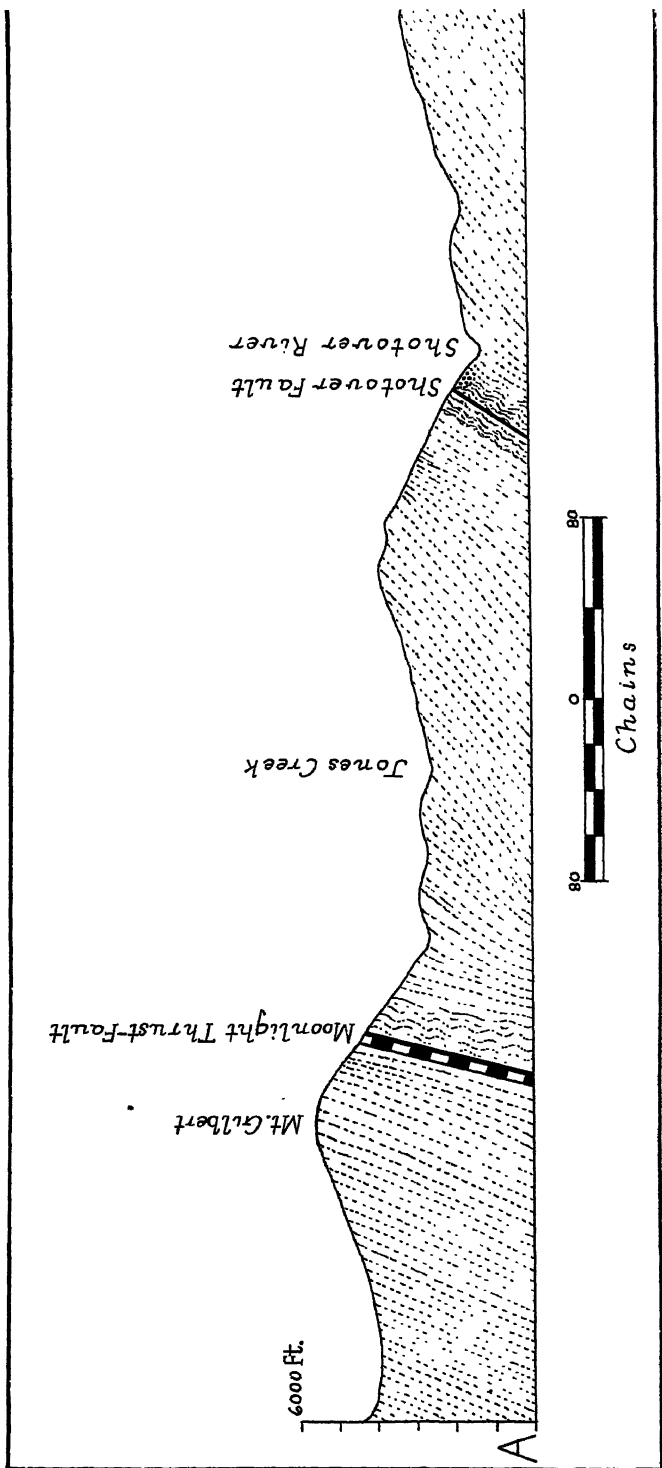


FIG. 6.—Section along A-B in Fig. 1, showing variation in angle of dip of the metamorphic rocks.



## New Zealand Foraminifera : Key Species in Stratigraphy. No. 2.

By H. J. FINLAY, D.Sc.

Micropalaeontologist, N.Z. Geological Survey.

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by the Editor, December 18, 1938; issued separately, June, 1939.]

IN the descriptions here given are included notes on stratigraphic occurrence and limits as completely as possible. This will enhance their value to the stratigrapher, and enable them to be used more precisely in all the Dominion areas where oil search is being carried out. As mentioned in a previous number, topotypes will, in most cases, be available for outside workers willing to reciprocate, and will in any case be sent to the Cushman Laboratory and to the Parr collection, Melbourne. The actual types are all in cases in the New Zealand Geological Survey collection.

### *Textularia zeaggluta* n.sp. (Plate 14, figs. 65, 66.)

Shell of medium size, rather narrowly tapering, initially compressed, rapidly becoming swollen, built of fine sandgrains and much cement, which shows only on middle of later chambers; rest of surface being roughened like sandpaper. Earliest chambers indistinct, but ending in a rather large blunt proloculum. Microspheric form very compressed initially, megalospheric form not nearly so much. Both forms widening rapidly at first for about one-fifth or less of shell, thence with sides slightly diverging, regularly thickening anteriorly; apertural section a little over half as thick as wide. Seven to eight chambers on each side in megalospheric form, regularly convex and inflated; terminal one slightly flattened and with a very small rounded aperture at its base. Sutures almost horizontal; on earlier quarter inconspicuous, on later whorls progressively deepening to become quite prominent channels between anterior chambers and down central line, always with a thicker deposit of sandy material than rest of chambers. Periphery flatly rounded, centre of front and back face lightly excavate.

Length, 1.5 mm.; width, 0.7 mm.

Holotype from loc. 5371, main road 1 mile South of Wanstead Hotel. Horizon, type Wanstead (= Upper Bortonian), i.e., Mid Eocene.

This is quite closely allied to *agglutinans*; typical Recent West Indian specimens of that species are only about half the size, but even then have a longer and lower aperture, do not inflate so rapidly after the very compressed initial chambers, have narrow clear-cut sutures, and altogether lack the sandpaper texture of the New Zealand form. It is much more like the Italian Eocene *T. lontensis* Lalicker (1935, p. 49, pl. 7, figs. 2, 3), but has a smaller aperture not set in a re-entrant, and deeper later sutures.

This is a common species in the New Zealand Eocene, especially in the Wanstead facies. It occurs but rarely in the actual Hampden section and in the South Island generally, but is abundant in Poverty Bay in certain beds referable to the Te Hua formation. It is not in the Cretaceous and, though it carries on into the Whaingaroan (e.g. 5357, Upper Point Elizabeth beds; 1242, Awakino River), it is usually replaced in the Oligocene by a species extremely similar in all sculptural and chamber details but differing at sight in being much more slender, almost cylindrical; this may be called *Textularia cuspidata* n.sp. (plate 14, figs. 63, 64), the type being from loc. 5182, Cormacks, lowest part of Oamaru limestone, just above diatomaceous earth; horizon Kaiatan, i.e. Lower Oligocene. This species is frequently met with in the Whaingaroa beds, and strongly recalls the American Upper Eocene *T. recta* Cushman, but has deeper sutures all over, more upwardly inclined.

***Textularia marsdeni* n.sp.** (Plate 14, fig. 67.)

Shell moderately large, elongate, three to three and one-half times as long as wide; built of very fine sand grains, obscured by much cement. Surface only slightly roughened, though heavily sculptured; initially compressed, with a sharp keel regularly increasing in thickness and more slowly in width. Terminally sub-oval in outline, about one and a-half times as wide as thick; the keel becoming evanescent. Sutures inclined upwards at about 20° from horizontal; mostly obscured by sculpture but on last few chambers forming distinct grooves. Chambers on later whorls only lightly convex, almost flush with surface; on earlier chambers they develop a heavy ornament of medial thick bars, completely crossing each half of shell alternately, with deep gutters of about same width between. There is a more or less pronounced double carina diverging up centre of shell enclosing about one-third of surface area; on the edges of this area the horizontal bars thicken into irregular knobs; this medial sculpture tends to weaken anteriorly. There are no fistulose projections. Aperture normal, a narrow slightly curved slit at base of last chamber, about one-third width of shell or a little more; terminal face somewhat flattened above it.

Length, up to 2.5 mm.; width, up to 0.8 mm.

Holotype from loc. 5274, Marsden, 6 miles South of Greymouth, "Blue Bottom." Horizon Hutchinsonian (Lower Miocene).

The species is abundant at this locality and is restricted to Lower and Upper Hutchinsonian. It occurs in the highest horizons at Terakohe Marl Quarry, Takaka; in the Burnside sandstone; in the Trelissick Basin Tuffs (5054); in the *Lepidocyclina* basal Ihungian bed, Poverty Bay (3003), etc. It is also in the Janjukian and Balcombian.

This form is one of the *agglutinans* group and in some respects resembles one of the figures given by Brady (*Chall. Zool.*, vol. 9, pl. 43, fig. 1), but the sculpture has distinct tendencies towards the group of *corrugata* Heron-Allen and Earland, though the latter is much wider and without the median double row of knobs. There are

numerous species masquerading as the West Indian *agglutinans* d'Orbigny, which Cushman has defined (1922, p. 7, pl. 1, figs. 4, 5) and recorded from the tropical Pacific (1932, p. 10, pl. 2, figs. 5-7). I have also seen Indo-Pacific specimens very similar to West Indian topotypes, but the species is quite different in sculpture from the present one and is not known to me from New Zealand. Chapman (1926, p. 29, pl. 7, fig. 12) has figured for this species a form which he recorded as typical and common in the Awamoan of Pukeuri; it is not in the least like true *agglutinans*, belonging to a different genus. It has a spout aperture, and is close to examples I have of *T. heterostoma* Fornasini from 77 fathoms off Ireland, as figured by Heron-Allen and Earland (1916, p. 229, pl. 40, f. 22, 23), but is much less compressed, the chambers being roundly inflated, with a groove but no flat hollowing down the centre; it may take the name *Siphotextularia awamoana* n.sp. (plate 14, figs. 89, 90), the holotype being from Awamoa Creek (5124). Rather curiously, a form very close to *S. heterostoma* occurs with it and is known from well back in the Tertiary and onwards till the present.

Two forms much closer in style of shell and sculpture are *Textularia agglutinans* var. *fistula* Cushman (1911, p. 10, fig. 11) from 200-300 fathoms North Pacific, and "*Textularia rugosa*" as figured by Brady (*Chall. Zool.*, vol. 9, pl. 42, fig. 24). The former differs in many details of sculpture and aperture, while the latter has been re-described as *Gaudryina rugulosa* Cushman (1932, p. 15).

Two forms described by Karrer (1864, p. 78) from the Hutchinsonian of Orakei Bay need examination:—*Textularia hayi* (l.c.; pl. 16, fig. 17) and *T. convexa* (pl. 16, fig. 8). The latter I cannot decipher at present, and it may be a *Gaudryina*; the former has been referred by Chapman (1926, pp. 4, 40) to *Bolivina punctata*, which the size alone makes an impossibility. It is obviously the large, very elongate, indistinctly sculptured form occurring together with *marsdeni* in the Waitemata beds. The sculpture of the two is very similar, but much feebler in *hayi*, which has a different shape and is probably ancestrally related to the Recent *T. stricta* Cushman (1911, p. 11, fig. 13; see also 1921, p. 107, pl. 21, fig. 1); this is quite a common form in Recent North Island dredgings, but is not known in the South Island, nor in the Tertiary.

The present species is named after Dr. E. Marsden, Director of the Department of Scientific and Industrial Research, who has been responsible for geophysical work in the Greymouth area; the locality name is a coincidence.

***Verneulina browni* n.sp.** (Plate 14, figs. 72, 73.)

Shell large, triangular, with sharp angles and many chambers; usually tapering fairly regularly to a sharp posterior point, but often with greatest width one-third of length from aperture, thence with a curved posterior taper and a much slighter anterior one; built of fine sandgrains in much cement. About 12 chambers on each side meeting in a zigzag central line between keels, which are sharp over the whole shell with practically flat surfaces between. Posterior ends of chambers form small backwardly pointing serrations along

keels. Sutures inconspicuous, terminal three chambers angularly flattened at top. Aperture a small subcircular opening with a narrow rim, situated in a small depression at junction of the three chambers. The general appearance is very like that of *Gaudryina proveussi*, but it lacks the biserial stage and has a different aperture.

Length, 1.7 mm.; width, 0.7 mm. to almost 1 mm. (micro-spheric).

Holotype from Kakanui limestone (5181, Kakanui Point, 70 chs. at 82° from trig V); coll. by D. Brown. Horizon Whaingaroan, i.e. Mid-Oligocene. This is abundant at the type locality but has not been seen elsewhere in the Whaingaroan. It is also abundant in the Terakohe Marl, Takaka (5055, highest horizon), and occurs in the Burnside sandstone (5072, 6 ft. above glauconite band), so that its range extends to the Hutchinsonian. It has been seen neither above nor below these limits. The figured paratype (fig. 73) is from 3312, Waitemata beds, and is less finely grained and tapering, but the Takaka shells agree exactly with the type.

The Cuban Eocene *V. villarensis* Cushman and Bermudez (1937, p. 1, pl. 1, figs. 1, 2) is similar, but more elongate, with more foliate keels.

***Gaudryina fenestrata* n.sp.** (Plate 14, fig. 68.)

Shell fairly large, elongate; triangular apical portion with sharp angles, relatively smooth, and of very small extent compared with rest of shell, which is about five times as long. Later part of shell quadrangular-rhombic in section, front and back practically flat, sides with a low but acute medial angle. From the three initial angles other keels diverge or are intercalated to enclose on front and back a long pointed area which widens more rapidly than shell outline, so that the impression is given of keels converging posteriorly to meet the triangular ones. Another sharp keel runs medially down the sides. All these keels are connected by horizontal ridges outlining the chambers; anteriorly these thicken and widen; on sides they are curved, producing a fenestrate effect. About seven biserial chambers on each side follow the triangular part; they are horizontal with grooved sutures between. Aperture normal, a small rounded opening at base of terminal face, which is flattened and not inflated.

Length, reaching up to 1.8 mm.; width, 0.75 mm. Thickness about two-thirds width.

Holotype from loc. 5274, Marsden, six miles South of Greymouth, "Blue Bottom." Horizon Hutchinsonian (Lower Miocene).

This species is never abundant, but is highly characteristic and limited to the basal part of this horizon. It is the only ornamented species of *Gaudryina* so far known in New Zealand.

The form at once recalls the figures given by Heron-Allen and Earland (1915, pl. 47, figs. 7-9) of their "*Gaudryina* variety of *Textularia rugosa*," but the two keels along front and back are broken up and much closer together, as in the case of Brady's figures of *rugosa*; the figure given by Cushman (1932, pl. 4, fig. 1) when he

named this form *G. rugulosa* is not at all like the New Zealand shell. A more closely related shell is the Australian Tertiary species which Heron-Allen and Earland (1924, p. 142, pl. 8, figs. 23, 25) figured from the Batesford Miocene as *G. rugosa* d'Orb.; it is, of course, not this Cretaceous species, and has the latticing much less defined than in *fenestrata*.

**Gaudryina (Pseudogaudryina) proreussi** Finlay. (Plate 14, figs. 69–71.)

1939. *Ibid.*, Finlay, *Trans. Roy. Soc. N.Z.*, vol. 68, pt. 1, p. 511.

Figures of the holotype and paratypes are here presented.

Large and typical specimens recently were found in the quartz glauconitic sands directly under the Amuri limestone, East Grey stream (coll. B. H. Mason, above lower Bortonian grey clays); also in the Chalk Marl lower part of the Amuri stone in the Motunau area (coll. B. W. Collins); and it occurs in the lower Amuri flint-stone at Conway Mouth (coll. J. Marwick)—defining all these as Bortonian.

In America, *G. jacksonensis* Cushman, with similar sharp angles but higher and fewer chambers, is common in the deeper-water Eocene, but is noted by Hedberg (1937, p. 667) to reach the Miocene in Venezuela, and develops into the Recent blunt-angled *atlantica* Bailey. In New Zealand, the sharp angled *proreussi* is limited to the Middle Eocene, and its blunter-angled descendant *reussi* does not usually survive the Middle Oligocene, Whaingaroan horizon; it has occurred, however, in samples from four different localities at the very base of the Grey Marls, just overlying the Weka Pass Stone—5641 (Weka Creek; coll. B. H. Mason, also A. A. Olsson), 5648 (East Grey River; coll. B. H. Mason), and 5636 (Lower Gorge of Motunau; coll. B. W. Collins). Other forms also mark this distinct horizon as the same in each case, and *P. reussi* does not pass beyond it. The implications of this occurrence will be discussed elsewhere.

**Clavulinoides olssoni** n.sp. (Plate 14, fig. 76.)

Shell large, elongate, triangular and with sharp keels over whole length; composed of large and small sand grains set in much cement, giving a coarse but smoothly finished appearance. Initial, triserial part with the usual sharp angles, the surface between them smooth and distinctly hollowed, giving a pinched-in appearance; chambers quite indistinct; at the end of this portion there is a small but distinct change, the keels suddenly drop a little in height and there is a faint twist to the shell; the narrow hollowing ends and is replaced by a broad slightly concave surface between keels. The latter rapidly increase in strength again and remain high and sharp on to base of last chamber. About six uniserial chambers. Sutures between keels strongly arched and forming shallow excavations, sometimes obscure; their meeting on keels forms downwardly directed corrugations, slightly interrupting keel. Aperture terminal, small, raised above chamber surface by a very slight neck irregularly weakly notched all round.

Length, up to 2.4 mm.; width, 0.8 mm.

Holotype from loc. 5390, Rotokautuku Creek, Poverty Bay. Horizon, Middle Ihungian, i.e. Hutchinsonian.

This is a very characteristic species of this horizon and is not known out of it. It is abundant only at the type locality, but has been seen also in the lower Mahoenui and in the Greymouth "Blue Bottom." It is named in honour of Dr. A. A. Olsson, Geologist of the New Zealand Petroleum Co., who collected the type sample.

This is, of course, similar to the *tricarinata-pacifica* group, being actually more like the former, but both these species are more smoothly finished and have a relatively wider aperture, with a tooth and practically no neck. Forms allied to *C. pacifica* are common in the Recent and Pliocene Australian fauna, but do not occur in the New Zealand Upper Tertiary or Recent. A Cretaceous relative is *C. aspera* and especially its variety *whitei* Cushman and Jarvis (1932, p. 19, pl. 5, figs. 6-8) which seems to occur also in the New Zealand Upper Cretaceous Moeraki beds. One of the closest relatives is apparently the Cuban Eocene *C. subulatus* Cushman and Bermudez (1937, p. 2, pl. 1, figs. 8, 9), but this has a produced triserial portion; no form of this type is known from the Eocene or Oligocene of New Zealand.

Smooth triangular forms of *Clavulinoides*, however, occur here in the Tertiary, but are not of much zonal value. One of these is not uncommon in the Ihungian and Tutamoe, and is similar to several of the Cuban Eocene forms described by Cushman and Bermudez (1937, pp. 2-4); from *C. cubensis* it differs in having only three uniserial chambers instead of five and in being smaller (1.5 mm. in length instead of 2 or more); from *eucarinatus* in its sharply keeled early portion; and from *marielinus* in its large aperture—it has much higher, sharper and more compressed keels, with more concave interspaces than any of the Cuban species. There is more similarity indeed to the well-known European early Tertiary *C. szaboi* Hantken, recently well figured by Ostrowsky (1938, p. 352, pl. 24, fig. 7) from the French Morocco, but this has a longer and sharper triserial part. This New Zealand form may be called *Clavulinoides instar* n.sp. (plate 14, fig. 77), the holotype being from G.S. 1342, Waikura Stream, Patutahi S.D., Poverty Bay, "just under Tutamoe boundary"; horizon Tutamoe, i.e. Middle Miocene. Accompanying this species is a second much larger form which is most like the Cuban *C. excurrens* Cushman and Bermudez (*l.c.*, p. 3, pl. 1, figs. 14, 15) but differs in having a shorter and more swollen initial portion, the rest of shell tapering to anterior end, and in having moderately sharp angles to keels, especially initially; it is the same size (1.5 mm.) and has also only two uniserial chambers. The name *Clavulinoides virilis* n.sp. (plate 14, fig. 78) may be applied to it, the holotype being from loc. 5373, Weber mudstone, Mangaotero Surv. Dist., Dannevirke Subdiv., 33 chs. at 64° from trig AK; horizon below Ihungian probably in this case Waitakian, i.e., Uppermost Oligocene. This species has, however, been seen in the Mahoenui beds and the Marsden "Blue Bottom"

(5277A) of Hutchinsonian age, and as far up as the Taranakian (5558, Jedburgh grey marls, Cheviot); both species occur together in the Dannevirke Ihungian (5347, Pourere Surv. Dist.) and "Weber" (5373), and *instar* has been seen in the Lower Bortonian (4192). No such forms occur, however, in our Cretaceous.

Genus *ARENODOSARIA* nov.

Genotype (original designation): *Clavulina robusta* Stache, 1864; *Reise der Novara*, Pal., vol. 1, p. 169, pl. 21, figs. 9, 10 (Mid. Oligocene, New Zealand).

This is proposed for a few species which are not happily placed in *Martinotiella*. Stache's *robusta* is the most extreme form and as such is taken as the type, but his *Clavulina antipodum* (l.c., p. 167, pl. 21, figs. 3-8) is referable here, as is also, in my opinion, *Clavulina elegans* Karrer (1864, p. 80, pl. 16, fig. 11). The latter species has recently been fully dealt with by Parr (1937, p. 75, pl. 15, figs. 4-8), who has pointed out that a small biserial stage follows the initial bulbous portion. Actually this stage is a very brief transition from the bulbous apex to the uniserial portion; in all other respects, including the important and peculiar aperture (well figured by Parr), and details of both juvenile and adult, the species is so unlike *Listerella primaeva* and so closely related to *antipoda* and *robusta* that I prefer to associate it with them. Parr (l.c., p. 76) found no biserial stage in those species and referred them to *Martinotiella*, but that genus is described by Cushman as having "typically an elongate, narrow, arcuate opening about a rounded tooth, sometimes with a slight lip," and his figure of topotypes of *communis* (*Illustrated Key*, pl. 8, figs. 6-8) show that this is not the same kind of aperture as exists in *robusta*. There is a line of several species throughout the Tertiary in New Zealand which has a distinct spout aperture somewhat like *Uvigerina*, and even to this group *Martinotiella* doubtfully applies, but they are all long, slender species, with the uniserial portion far outweighing everything else in proportion; *robusta* and its allies are large stout shells with far fewer uniserial chambers and an early bulbous portion, forming one quarter to one third of the shell. The aperture in juveniles is a vertical slit (sometimes almost Bulimine); in the adults a central opening surrounded by a notched rim (as in *Nodosaria* but cruder), which may finally become almost cribrate; it may be somewhat elevated, but there is no real spout. It seems to me more like a development from *Plectina*, while *Listerella* is a continuation from *Karrieriella*, and *Martinotiella* from *Arenobulimina*.

I would therefore define the genus as having a large, bulbous triserial part, with a polyserial beginning; sometimes followed by a very short biserial stage; the aperture developing from a juvenile Bulimine slit to a Lageniform raised, fairly large, central opening; test coarsely arenaceous, with not much cement.

*Listerella* should not be used for any species which has not a spout aperture as in the genotype and in *Karrieriella*.

Chapman (1926, p. 36) has placed *robusta* as "an incrassate form of . . . *antipodum*"; this may be so, but the two are usually easily distinguished and have different ranges, so are best kept apart. At first sight some localities (such at Otiake) seem to show the two

grading, but this is due to the large size reached there by *antipoda*. The latter is abundant throughout the Upper Bortonian, Kaiatan, Whaingaroan and Waitakian. In the Hutchinsonian it is sometimes common in the lower part, but tends to become rare as the Awamoan is reached, and after that it becomes infrequent. The much larger *robusta* is considerably more limited in its range, both above and below. It is abundant throughout the Oligocene, occurring commonly in the Duntroonian-Waitakian, but is rare in the true Hutchinsonian, where *antipoda* is often common (Marsden "Blue Bottom," Waitemata beds, Makara facies of Ihungia, etc.). It is common still in the Uppermost Eocene (Tahuian of Burnside Marl and top of Hampden section), but rare or absent in the Bortonian. The genus has never been seen from the Cretaceous, so that its presence, with *Pseudogaudryina proreussi* in several Waitangi No. 1 Well cores, down to 1450 ft., is still further evidence that these bentonites must not be correlated with the surface outcrops of *Rzehakina* red shale.

The only other large form of this kind in the Tertiary is the species *bradyi* Cushman (1911, p. 73, figs. 118, 119); this is referable to *Martinotiella* s.l., and occurs from the Whaingaroan to the present time in New Zealand.

*Listerella weymouthi* n.sp. (Plate 14, figs. 80, 81.)

Shell large, cylindrically club-shaped, bent and twisted, with large triserial part, few biserial, and several uniserial chambers. Triserial together with biserial part swollen and elongate, variable in length, but usually half or more of shell, initially polyserial, more or less twisted, the last three or four chambers biserial; four to five cylindrical uniserial chambers follow suddenly with a decrease in width to about two-thirds, nearly always irregular and somewhat staggered. Sutures indistinct, except on last chambers, aperture in triserial and biserial stages exactly as in *Karrerella*, finally becoming in uniserial stage a central projecting spout situated in a slight depression.

Length, up to 2.3 mm.; major width, 0.7 mm.

Holotype from loc. 3089, base of alternating series North of Whangara, Poverty Bay. Horizon basal Tutamoe, i.e. Mid-Miocene.

This is a conspicuous species which cannot be mistaken, though at some localities specimens with uniserial stage are rare. It is usually abundant in the Lower Tutamoe sandy facies, but it occurs also in the Ihungian (5347, Pourere Surv. Dist. and many Poverty Bay localities) usually sporadically, but sometimes rather commonly: it is in the Pukahika, and extends down to the Maungatapere (4141 Waikura Stream; 3308, Coast, 2 m. W. of Tatapouri) and the equivalent so-called "Weber" (5373, Mangaotero Surv. Dist., Dannevirke), which is not true Weber.

The species is named after Mr. A. Weymouth, geologist of the New Zealand Petroleum Company.

***Listerella levis* n.sp.** (Plate 14, fig. 79.)

Shell small, appearing very simple and primitive in structure, formed almost entirely of fine cement, which is very largely calcareous and soluble in acid. Initial chambers indistinct, but apparently more than three per whorl (at least in microspheric form); very quickly reduced to three and that almost at once to two, the impression given being simply of an early more than biserial bulbous part. Biserial portion of about four to six chambers; roughly equal in length to earlier part but variable. A final uniserial stage of about six chambers develops suddenly as in *Bigennerina*, and is similarly staggered at a slight angle to biserial axis. Chambers simple, convex, more so anteriorly; sutures forming distinct grooves. Aperture terminal, central, forming a small spout.

Length, 0.8 mm.; width, 0.1 mm.

Holotype from loc. 5371, main road, 1 mile South of Wanstead Hotel. Horizon, type Wanstead (= Upper Bartonian), i.e. Mid. Eocene.

This is a characteristic and not uncommon form in the Wanstead horizon, and occurs at many places in the Dannevirke area and in the Poverty Bay Te Hua beds. It is not in the Cretaceous, but reaches the Lower Ototaran, occurring commonly in the Kaiata mudstone (5332), and in a few indefinite samples from the "Weber." This formation name is still unsatisfactory; faunas seen from the type locality are too poor to be decisive, but seem to be Tahuian.

This species resembles *L. primaeva* the genotype, except in being very much smaller and in having more convex chambers and a much shorter biserial stage. It is very similar to the Panama Upper Eocene *L. anconensis* Coryell and Embich (1937, p. 295, pl. 41, fig. 12) but has more convex chambers and deeper sutures. I can see no resemblance, however, to the various species from the Cuban Eocene placed in this genus by Cushman and Bermudez (1937, pp. 5-6, pl. 1). These all seem to me to have much stronger affinity to *Martinotiella*; forms extremely similar are common in the New Zealand Lower Tertiary.

***Tritaxilina zealandica* n.sp.** (Plate 13, fig. 36.)

Acutely conical, posteriorly tapering evenly to a blunt point, swollen medio-anteriorly, slightly contracted towards aperture; built of large and small sandgrains in much cement. Four chambers per whorl, marked on later part of shell by very low angles where the heavily limbate sutural ridges meet in an irregularly sinuous pattern. Early third to half of shell distinctly five-angled, the angulations being sharper, higher and less sinuous than anteriorly and with fairly straight connecting limbations marking chambers. Sutural limbations rather narrow, high and bluntly rounded, leaving the depressions very long, relatively wide, with a flatly convex floor. In fully adult shell, chambers are reduced to three per whorl anteriorly, but no biserial stage has been seen. Aperture a small central opening at base of chambers as in *Gaudryina*.

Length, 2.25 mm.; width, 1.2 mm.

Holotype from Upper Point Elizabeth beds, loc. 5358, 1 mile North of Cobden Bridge, Rununga Road. Horizon Whaingaroan, i.e. Mid. Oligocene. A single good and typical specimen has also been seen from the Pukahika of Whangara Beach (3148), and a few from Marsden "Blue Bottom" (5277A).

This has the heavy basal sculpture of the Recent Pacific *caperata*, but in absence of uniserial chambers is more like the American *atlantica*; it cannot be confused with either, nor with the *Oligocene mexicana*, whose chambers and biserial portion are quite different. A nearer relative appears to be the Cuban Eocene *cubensis* Cushman and Bermudez (1937, p. 7; and 1936, pl. 10, figs. 25, 26), but this does not have the five early angles, nor anything like such long and deep depressions between the much heavier limbations. A form still more like *cubensis* occurs in the New Zealand Eocene and may be called *Tritaxilina languida* n.sp.; it has five initial angles, similar to *zelandica*, but the chambers are separated by grooved sutures without limbations; the deep pits that characterise *cubensis* are absent; the holotype (plate 13, fig. 38) is from loc. 5279, Wanstead mudstone, Motuotaraia Surv. Dist., 210 chs. at 20° from Trig. G, and it also occurs at 5573, chalk marl below Amuri limestone, Hurunui Mouth. (plate 13, figs. 37, 39).

The genus has been found at quite a number of localities, but mostly as odd specimens. It continues into the Cretaceous Whangai.

***Bolivina lapsus* n.sp.** (Plate 11, fig. 9.)

1926. *Bolivina limbata* of Chapman; *N.Z.G.S. Pal. Bull.*, no. 11, p. 40, pl. 9, fig. 6, *non* Brady.

This and allied species have been masquerading under Brady's name for many years. But, as plainly shown by the original figure and that of Cushman (1911, p. 48) the real tropical Recent species is a *Loxostomum*. Cushman's variety *costulata* (1924, p. 19, pl. 5, figs. 2, 3 and 6) from Samoa is very similar to the typical form (of which I have seen numerous Indo-Pacific examples) except in the addition of faint sculpture, and it too is definitely *Loxostomid*. The N.Z. shells never develop a terminal aperture, lack the pronounced twist and peculiar sides of *limbata* (very thick initially, regularly decreasing to almost a sharp edge anteriorly), and have a quite different chamber development. About the only feature in common is the sutural limbation, which differs in detail and is found on many species. There are forms in the Australian Balcombian much more like true *limbata*, but these are apparently absent from New Zealand.

*B. lapsus* in general style of shell and limbation really more resembles the Cretaceous *incrassata* Reuss (see Cushman, 1921, p. 49, pl. 8, figs. 2-4—other figures seen less resemble *lapsus*). This species occurs in quite typical form and size also in the New Zealand Upper Cretaceous, being abundant in the Lower Rakauora formation (3249, block 1, Waipiro Surv. Dist. and occurring as smaller specimens. (which Cushman also notes) in Mangaotero Surv. Dist., Dannevirke area (5374), and at Tuparoa Stream (3250A) above 3249; the species is marked by its swollen proloculum, sutures sloping more steeply

with age up to 60° from horizontal; chambers about half as high as long, and very small aperture. It has recently been found in the Waipara greensands (5665) of the type Piripauan, which correlates remarkably in its foraminifera with the Rakauroa and Tapuwaeroa.

The New Zealand Miocene species was recorded by Chapman as rare, but it is often extremely abundant in the Hutchinsonian, e.g., the Mahoenui and Ihungia beds, Marsden "Blue Bottom," Waitemata Beds, etc. The holotype is chosen from Pakaurangi Point (G.S. 1189) and is 0.7 mm. in length, and about one third as wide; all chambers very distinct, at a constant angle of 45° throughout shell, which is so minutely perforate as to appear smooth and translucent. Sutures straight, meeting at sharp angles, formed of vitreous matter, slightly more concentrated at upper angulation; periphery everywhere bluntly rounded; aperture rather large and widely open, not free of previous chambers. The species carries on into the Awamoan (common at 5273, All Day Bay) and Tutamoe, and is in the Taranakian (Kaiti beach section) but not above this; it is common in the Pukahika, but extremely rare below this, though a few undoubted examples occur in the Whaingaroan (loc. 1278, 1 mile S.E. of Raglan). It thus has a range throughout the Miocene and penetrates rarely to the Middle Oligocene.

***Plectofrondicularia pellucida* n.sp. (Plate 11, fig. 7.)**

Shell small, fragile, pellucid, compressed, elongate, about 6 to 7 uniserial chambers, sutures very steeply curved, but inconspicuous, often shown only by translucency of chambers. Microspheric form beginning as a sharp point, widening at about 45° for a short distance (about one-eighth of length), thence with but slightly diverging sides; megalospheric form similar, but with blunter apex (composed of spherical proloculum), smaller and more narrowly diverging biserial part. The latter is well marked off in microspheric shell by being slightly contracted at close and slightly thickened; biserial chambers about 3 on each side, mostly obscured by surface sculpture. This consists of about 9 equidistant hair-like threads that run evenly over the whole shell. On biserial part there are 1 to 3 additional short, irregular, raised ridges. Sides very compressed but rather bluntly angled.

Height, 1 mm.; maximum width, 0.2 mm.

Holotype from Eketahuna mudstone (5207) on roadside just South of the town. Horizon Opoitian, i.e. Lowest Pliocene. This is usually a not uncommon form in Opoiti faunas and may be of use in distinguishing that horizon. It is the "*Plectofrondicularia* sp." already referred to by me (1939A, p. 530) as first occurring in the Opoitian; specimens are, however, known also from the Nukumaruan (5395, Devil's Elbow), and one from the Castlecliffian (5212). In the Opoitian of Hicks' Bay (G.S. 1155) it occurs together with the typically Upper Miocene *P. pohana* Finlay.

The species somewhat resembles the American Upper Eocene *P. cookei* Cushman (see Cushman, 1935, p. 34, pl. 12, figs. 11, 12), but is much smaller and finer, without the apical swelling; it has the

same sutures. In the Awamoan, there is a Miocene ancestor of *pellucida*, much more like *cookei* in general size, shape and apical thickening due to the bulbous proloculum; also in the uneven sculpture, the central ribs being stronger and more prominent, while those of *pellucida* are even all over. The New Zealand Miocene form differs at sight, however, in its extremely highly arched chambers, which even at first are higher than broad and become almost twice as much so. This form may be called *Plectofrondicularia awamoana* n.sp., the holotype being from All Day Bay upper marls (5273), and one specimen also occurring at Awamoa and in the Tutamoe of Island Creek, Poverty Bay, and in the Hutchinsonian Caversham sandstone at Burnside (5073).

***Bulimina bortonica* n.sp.** (Plate 12, figs. 25, 26.)

Shell small, about one and three-quarter times as long as broad, microspheric form gradually tapering to a definite slightly blunted point; megalospheric form with a flatly domed top. Sutures distinct but shallow; chambers irregularly slightly inflated, roughly pentagonal in shape; in outline somewhat excavated on four of the sides (which are quite irregular in length), convex on side meeting next chamber. This gives the chambers a peculiar indented effect, where they join upper chambers near aperture. Surface smooth; apertural oblique truncation and excavation relatively large, but aperture itself fairly small, set in a hollowed out area, which is visible from back as a rounded notch in base.

Length, 0.35 mm.; width, 0.2 mm.

Holotype from Hampden section (5179B, 1½ miles North of Kakaho Creek).

This is a common and ubiquitous Bortonian species occurring abundantly throughout the Hampden section, in the Wanstead formation of Dannevirke, the Te Hua beds of Poverty Bay, and the Pahi greensands. On this occurrence alone the beds mentioned can be safely correlated, for the species is completely limited to, and a characteristic index fossil of, the Lower and Upper Bortonian, missing even from the Tahuian.

An allied form occurs very rarely in the Upper Cretaceous (e.g. 5301, Mangaotero Surv. Dist.), but lacks the excavation depression in the chambers and the basal apertural notch. The two species are related to such forms as the Cuban Eocene *B. tarda* Parker and Bermudez, the French Eocene *B. simplex* Terquem, and the American Cretaceous *B. exigua* Cushman and Parker, but differ in several details.

***Uvigerina maynei* Chapman.** (Plate 11, fig. 6; plate 12, figs. 18, 19.)

1926. *Uvigerina maynei* Chapman; N.Z.G.S. *Pal. Bull.*, no. 11, p. 70, pl. 14, fig. 6.

This was described from the Oxford Chalk, North Canterbury, referred by Chapman to the Upper Cretaceous. The only analogy this locality or fauna has with Cretaceous is the word Chalk; topotypic material easily washes to yield a good fauna, very different in

size and preservation from what appears on Chapman's original slide. This contains 32 specimens allocated to 16 species; almost all are fragmentary, most are pieces of *Gyroidina* and *Cassidulina*, in the latter case being referred to three different genera and containing also bits of *Rotaliatina*. It would serve no purpose to discuss the identifications separately; the fauna is referable to the Whaingaroan Upper Ototaran, i.e. Mid. Oligocene, matching most closely.

In the case of *maynei*, it is evident that the original figure is peculiar and a careful examination will disclose that what Chapman took and figured for the anterior chambers and aperture (top right hand half of the figure) is adhering matrix, the apertural part being really the angularly truncate basal part of the figure, with the spout broken off. If this figure is inverted and compared with that of "*pigma*" (fig. 7, same plate) the analogy is obvious. The matrix is soft, and the unique holotype was easily cleaned, exposing a posterior sculpture of sharp narrow ridges, especially prominent over apex as jutting short blades. A topotype is here figured to show this effect (plate 11, fig. 6), also a Whaingaroan specimen (plate 12, figs. 18, 19) from loc. 5155, below Te Kuiti limestone, on road about 3 miles S.W. of Pakeho School.

The species is of the general *schwageri* line, but differs at sight from that species and its Tertiary relatives such as *alazanensis* Nuttall and *gesteri* Barbat and von Estorf in its far more numerous ribs, jagged apex, etc.; there are many somewhat similar species, such as the Upper Eocene *cocoaensis* Cushman, characteristic of the Jackson, and the Oligocene *gallowayi* Cushman, but this New Zealand form has a short range and is undoubtedly distinct. It is strictly limited to the Whaingaroan, and is usually abundant when present. Apart from the Oxford Chalk it is rare in the South Island (not seen so far in the Kakanui limestones or Cobden beds), but occurs at several places in the Poverty Bay Maungatapere (e.g. 4283, North of Trig. W9, Waingaromia; 5365, Waikura Stream, etc.). From all the species described below it is distinguished by smaller shell, with practically no tendency to triangulation, and especially by the high plate-like character of the ribs posteriorly—starting inconspicuously at the lower sutures, they strengthen as they run up to form a more or less prominent shoulder just below upper suture, where jutting blades of uneven strength become more and more marked to culminate in a crown round apex. The ribs and apex are never smoothed off, but sculpture is obsolescent on lower half of last few chambers.

In a horizon just above Whaingaroan, probably Waitakian, there occurs at several localities a closely related form, *Uvigerina dorreeni* n.sp., which differs from *maynei* chiefly in reaching a larger size, tapering more acutely posteriorly, showing a distinct triangular habit, like the still later *miozea*, and having the aperture tending to move away from the junction of chambers to the isolation more typical of *Siphogenerina*; the sculpture of pointed plates is variable and sometimes almost disappears, foreshadowing the later developed *U. paeneteres*, which has quite blunt angles and inflated chambers. The holotype is from 5363 ("grading beds," 100 ft. above Cobden limestone, but below Hutchinsonian); other records are from basal Grey Marl of

Weka Creek, lower Hutchinsonian *Pachymagas* beds of All Day Bay, Dannevirke "Lower Ihungian" (5344, 5383, above upper Wanstead), and in part of a large section (in Hawke's Bay) above Wanstead and below typical Ihungian.

An important fact is that this line does not occur at all in lower beds. Although species of *Hopkinsina* are common in the Kaiatan, Tahuian and Bortonian, no representative of the *pigmea-schwageri* group, so abundant in our Miocene, has ever been seen. The genus itself stops abruptly with the Bortonian and has no members in our Cretaceous.

### *Uvigerina pigmea* d'Orb.

This has been given both Tertiary and Recent occurrences in New Zealand, but there are so many generally similar forms distinguished now in other countries that few, if any, of the shells examined by Chapman, Heron-Allen and Earland, etc., would pass the test of a close comparison with Italian Pliocene topotypes. These have been fully revised and illustrated by Cushman (1930, p. 62, pl. 3, figs. 14-20). It is interesting that at one horizon in the New Zealand Lower Pliocene (Wairoa beds, e.g. 2102, Clyde Surv. Dist., Pov. Bay, on Wairoa Road, West end of Lake Whakaki, examples do occur which are almost identical with Cushman's figures, and for these the name *pigmea* may be used. Other records will have to be distributed amongst different species. Shells of this general type occur as high up as the Kai-Iwi beds, but have not been seen so far in the true Castlecliff beds; this appears to be one of the few ready distinctions between the Castlecliffian and the underlying Kai-Iwi and Nukumaruan.

### *Uvigerina miozea* n.sp. (Plate 12, figs. 12-14.)

This is proposed for the common Ihungian form, the holotype being from loc. 5389, N. branch Mangaoporo River, Ihungia mudstone upstream from bridge. Only the one species occurs here, and is characterised by moderately large shell with a very polished appearance (as if water worn, even in perfectly preserved shells), a distinct bluntly triangular habit, a greatest inflation at lower two-thirds, narrowing to a blunt worn-looking point apically (sometimes bearing a few jutting points marking ends of ribs), ribs fairly numerous, 2-4 times their width apart, becoming strikingly finer and more plentiful on each succeeding chamber, aperture short, rimmed, and smooth. This species is extremely common throughout New Zealand in the Hutchinsonian, and I have it from the Marsden "Blue Bottom," the West Grey district, the Mahoenui beds, the Waitemata beds, and all through the Poverty Bay Ihungian and Tutamoe, in many samples. I have not seen it in the Pukahika, but it is in the topmost part of the Te Kuiti beds (5438), which seems to be its lowest limit. Examples from the Lower Hutchinsonian of All Day Bay and the "Grey Marls" of Weka Pass are close, but not typical, the ribs and apical points being stronger and less smoothed. A figure of this form, with abnormally sharp spikes, has been given by Chapman (1926, pl. 9, fig. 1) under the identification "*Bulimina inflata*"; his actual specimen shows the *Uvigerina* tube broken but

quite distinct. Such specimens should be referred to *U. dorreeni*. The South Island Awamoan forms seem inseparable from *miozea*.

A development from this form becomes almost entirely smooth, except for a few very distant and inconspicuous ribs in the first 2-3 apical chambers, slightly corrugating the blunt top; at the same time the groove which normally connects base of aperture to previous chambers disappears, and the aperture becomes entirely surrounded by last chamber, the semi-uniserial nature of which thus shows an approach towards *Siphogenerina*. This form, which occurs in the Upper Tutamoe and the Ihungian sandstone of Whangara (3029), may be called *Uvigerina paeneteres* n.sp., the holotype being from the Kaiti Beach section, Pov. Bay (3132, 400 ft. above alternating beds, 800 ft. below *Ammodiscus* bed of basal Taranakian); it is also present in the Upper Tutamoe of Muddy Creek (G.S. 1296; 60ft. above highest conglomerate).

*Uvigerina mioschwageri* n.sp. (Plate 12, figs. 15-17.)

This name is given to a development from *miozea* in which the shell is larger and more heavily sculptured. The worn appearance is not so evident, and every second or third rib becomes much stronger, developing into a posteriorly pointed wing. These are irregularly heavy on apical half of shell, but do not jut much beyond actual apex which has a single blunt spine or cluster of prickles. Interstitial areas between the plate-ribs may be almost smooth, but more often have a few riblets diminishing anteriorly.

Holotype from G.S. 1342, Waikura Stream, "just under Tutamoe boundary" (accompanying fauna Tutamoe). Horizon basal Tutamoe, i.e. Mid. Miocene.

This form seems to be absent from Ihungian sediments in Poverty Bay, but becomes increasingly the dominant form in the Tutamoe, where it has occurred quite often (e.g. G.S. 1342, Waikura Stream; 3109, Whangara, 900 ft. above base of Tutamoe; 1193, Mangatoetoe Stream; 3103, Knox Ck.; all Tutamoe and in Poverty Bay). It is accompanied there by dwindling numbers of *miozea*; elsewhere it seems to range down into the Hutchinsonian, for fig. 16 is of a specimen from Citrini's Area, near Kumara, Greymouth "Blue Bottom," where both species occur and are quite distinct; this may possibly be a higher horizon than the Hutchinsonian "Blue Bottom" of Marsden. Only the *miozea* type occurs in the Clifden Hutchinsonian. *U. mioschwageri* continues on abundantly into the Taranakian, specimens being quite common in 3137 (Kaiti Beach section, 100 ft. above base of Poha), etc.

In the three primary shell angles, *miozea* and *mioschwageri* strongly recall the Oligocene *Uvigerina cubana* Palmer and Bermudez (see Cushman and Edwards, 1938, p. 79, pl. 13, figs. 18, 19) which also has three main flanges and secondary plate-like ribs; *mioschwageri* is especially close to this species but seems to have a sharper apex and more numerous ribs, which are more twisted and less vertically continuous.

**Uvigerina** sp. cf. *interrupta* Brady.

This has been recorded by Parr (1934, p. 143) in a rock section from Chalky Island. The accompanying fauna is almost certainly Hutchinsonian and it is probable that Parr really had a member of the *canariensis* group. The tropical Indo-Pacific *interrupta*, with its strong uniserial tendency anteriorly, does not occur in New Zealand, and the record should be deleted.

**Hopkinsina** *bortotara* n.sp. (Plate 12, figs. 22-24.)

Shell with close knit chambers, roughly biserial; with many fairly strong, slender axial ribs, turning to prickles anteriorly. Shape elongate, three to almost four times as long as wide. Apex bluntly pointed in microspheric form, widely rounded and dome shaped in megalospheric form; like *H. notohispida* in these respects. Sides sub-parallel over middle half, bent in on upper third and less so on lower third, where the apertural and penultimate chamber is usually narrower than the others. Upper quarter to third (3 or 4 chambers) regularly triserial, rest of shell (5 to 6 chambers) roughly biserial, somewhat twisted and more and more loosely wound as aperture is approached, somewhat as in *U. interrupta*, but less extreme. Sutures fairly deep, over-ridden by axials. About 16 to 18 axials on each chamber, forming narrow raised but blunted ridges, one and a-half to two times their width apart; somewhat irregular, slightly inclined to anastomose, continuing fairly in line with axials of later chambers over most of shell but inclined to meet them at sudden, sharp angles where chambers are narrowest; on last two whorls there is a gradual more or less complete break up into isolated ridglets, or even small prickles, with a tendency towards a smoother surface. Aperture a fairly long tube about one quarter width of chamber with prominent lip and several concentric rings.

Height, up to 0.8 mm.; width, about 0.3 mm. Many specimens are relatively narrower than this.

Holotype from Burnside marl, near Dunedin (5068). Horizon Tahuian, i.e. Upper Eocene. It is common throughout New Zealand in the Eocene and Lower Ototaran, but is rare above this, being usually replaced in the Upper Ototaran and onwards by species of the "*pigmea*" group; however it is present at 5357 (Upper Point Elizabeth beds, Whaingaroan) and 3287 (lower part of Maungatapere, Pouawa Dome). It is possible that it does not extend into the Lower Bortonian, as in the Eocene it has been found associated only with Upper Bortonian or Tahuian faunas.

On the definition of the genus, this seems referable to *Hopkinsina*, but is not very like the style of shell figured for *danvillensis*, the genotype. It is plainly reminiscent of such Eocene forms as *U. spinicostata* Cushman and Jarvis and *U. havanensis* Cushman and Bermudez (see Cushman and Edwards, 1937, pp. 80, 83. pl. 12, figs. 2, 3, 11, 12), but differs in sculpture details.

**Hopkinsina** *wanzea* n.sp. (Plate 12, figs. 20, 21.)

A form of the previous species in which the reduction of the axials to prickles has proceeded almost completely. The whole surface is covered with minute pustules somewhat like but smaller in

degree than in *U. notohispida*. At first sight the resemblance to the latter species is close, but *notohispida* is considerably larger, has a much more pronounced difference in the microspheric and megalospheric apex and has no trace of linear arrangement in the close mat of flat-topped pustules, while *wanzea* has the prickles more separated and still in more or less vertical lines. The shape as a whole is stouter and shorter than in *bortotara*, with the sides hardly anywhere parallel; this gives it somewhat the appearance of the *canariensis* group, but it is larger and rougher than any of the latter in New Zealand. In the Whaingaroan Maungatapere formation (e.g. 4141) a species of that group closely simulates *wanzea*, but is smaller, with still finer prickles.

This form is common in the Wanstead facies of the Upper Bortonian, but occurs also at Hampden—together with *bortotara* at 5179B (Upper Bortonian) and alone at 5180 (Lower Bortonian). The holotype is from loc. 5371, main road 1 m. S. of Wanstead Hotel, type Wanstead.

**Hopkinsina notohispida** n.sp. (Plate 12, figs. 10, 11.)

This is the New Zealand Middle Tertiary representative of the Indo-Pacific Pliocene *Uvigerina hispida* Schwager (1866, p. 249, plate 7, fig. 95). It is the same in size, general features and loosely biserial anterior chambers, and the ornament consists of numerous rather coarse, prominent pustules, but these are much more crowded and closer together than in Schwager's figure. The latter shows quite sharp and high spines two to three times their own width apart and two to three times as high as broad. In New Zealand shells the spines are very rarely sharp, mostly low, rounded knobs, no higher than wide (generally less) and less than their own width apart; the microspheric and megalospheric forms differ radically in shape, the former being sharply pointed posteriorly and swelling anteriorly, the latter smaller, subcylindrical, with inflated domed apex. Schwager's figures are reasonably accurate, and, though I have seen no typical material, I am unable to identify this species with his. Cushman (1929, p. 95, pl. 13, fig. 35) has figured a Venezuelan Oligocene specimen as *hispida*, but shows the spines closer (though not as abundant as in *notohispida*) and remarks that they are blunt; Cushman and Edwards (1938, p. 83, pl. 14, fig. 6) have since named this form *Uvigerina rustica* and noted considerable differences from *hispida*. New Zealand specimens, while like *rustica* in coarseness of spines, have a still greater density, and lack the wide oblique aperture; in shape and aperture they more resemble *hispida*. Quite recently, Lacoste and Rey (1938, p. 320, pl. 21, fig. 12) have well figured, under the name *U. hispida*, a Burdigalian French Moroccan specimen which could easily have come from New Zealand. Their illustration shows just the points of difference from *hispida* and *rustica* I have commented on, and it would seem that *notohispida* occurs also in that area, where it does not range below Burdigalian.

Holotype from Poverty Bay locality 3141, Kaiti beach, 1700 ft. above "*Cyclamina*" bed, which marks base of Poha formation, Horizon, Taranakian, i.e. Upper Miocene.

In New Zealand this form is somewhat sporadic in occurrence, but frequently abundant, especially in tuffaceous sediments. It is liable to occur throughout the Tutamoe and Taranakian; the upper limit seen is basal Opoiti (Lowest Pliocene) and the lower limit is G.S. locality 1342 (Patutahi Surv. Dist., Poverty Bay, Waikura Stream), a horizon supposed to be immediately below the Tutamoe-Ihungia boundary, but with a definitely Tutamoe fauna. I have never seen this species from Hutchinsonian or lower beds. On the Taranaki side it is quite common in Mohakatino faunas and in the Amuri district occurs in the Cheviot so-called "grey marl" (5557A).

#### THE NEW ZEALAND SPECIES OF SIPHOGENERINA Schlumberger, 1883.

Of all the rhizopod genera in New Zealand this is one of the most useful in supplying key species. From the Eocene to the Upper Miocene the main formations may be distinguished with relative ease if species of this genus are present, though careful discrimination involving comparison of specimens is sometimes necessary. The species have a wide range, over most of New Zealand, and are largely independent of facies. The genus is used for forms directly derived from *Uvigerina* by the addition of a uniserial stage without any intervening biserial one; forms of the latter type are referable to *Rectobolivina*.

#### *Siphogenerina striatissima* (Stache).

1864. *Nodosaria striatissima* Stache. *Reise der Novara*, Pal., vol. 1, p. 198, pl. 22, figs. 25 a-f.

This was quite well and recognisably figured by Stache (except for an idealised initial portion), but nevertheless has been misinterpreted, due to his and Chapman's wrong generic locations. Chapman (1926, p. 51) as usual threw the name in synonymy, but his choice of the Cretaceous *paupercula* Reuss as an equivalent is erroneous even generically. Perhaps misled by this, Parr (1935, p. 77) has recorded Awatere specimens as *Nodosaria striatissima*, in spite of the enormous discrepancy in size between his fragment and Stache's species. His actual specimen proves to be what Stache called *Nodosaria callosa* (1864, p. 197, pl. 22, fig. 23), which is probably inseparable from his *obliquecostata* and *substrigata* (l.c., figs. 23, 22).

The real *striatissima* is a common fossil in the Whaingaroa beds, present usually in abundance in almost every sample, and shows at once by its triserial apex that it belongs to *Siphogenerina*. The triserial part is extremely small and well covered by sculpture, but the aperture is quite clear and not Nodosarian.

Of all our species this is the nearest in general habit to *raphanus*, but the ribs are very much weaker and more numerous, with typically a number of spinose projections at the posterior end, the chambers are more distinct, and the aperture is very weakly rimmed. In these respects it resembles *S. basispinata* Cushman and Jarvis (1929, p. 13, pl. 3, figs. 4-5) but is decidedly more elongate. It is characterised specifically by its very obscure, small apical portion (about one fifth the total length) hardly interrupting the shell outlines, which are

practically straight; the whole narrowly cylindrical, or slightly swelling anteriorly, the chambers hardly at all convex, uniserial ones numbering 6 to even 8 and the sutures very feeble. The ribs are narrow but fairly strong, numerous, about their own width apart, strongest posteriorly (and at apex jutting into small irregular spines) weakening anteriorly, evanescent on last chamber, and usually absent on base. The aperture is a very short, extremely slender, smooth spout, with a tiny fragile rim, usually broken.

The acicular form is characteristic, but there occur with it less abundant specimens, which are decidedly more slender still, quite cylindrical, and with faintly convex chambers and weaker sculpture; these are possibly distinct, but may be the megalospheric form.

The typical form is strictly limited to the Whaingaroan and overlying Duntroonian and, especially when abundant, unfailingly marks these Upper Oligocene horizons.

Apart from the actual Whaingaroa beds, the typical form has been seen only in the Upper Point Elizabeth beds (5357); Cobden limestone (5361); the uppermost Kakanui limestone (5181); the locality G.S. 1910, in Swinburn Surv. Dist., S.E. of Naseby; the 'Oxford Chalk, Canterbury (*Sagrina striata* of Chapman, 1926, p. 71, pl. 14, fig. 12; *non* Schwager); the Poverty Bay Maungatapere (4283, North of Trig. W9; and also 1176, North branch Wheao Creek); and the Amuri limestone. A Middle Amuri sample recently collected in East Grey district (5575) by B. H. Mason yielded a fauna containing *S. striatissima*, *Notorotalia stachei* Finlay and *Rotaliatina sulcigera* (Stache); this association supplies the first reliable evidence for the age of this classic deposit, and correlates this part of it with the Whaingaroan. Chapman (1926, pp. 10, 11) placed it in the 'Cretaceous on the basis of his record of *Gumbelina* and *Globigerina cretacea*; the former is common in the Ototaran and runs high into the Tertiary, while the latter occurs only in the Raukumara Upper 'Cretaceous formation and is not resembled by any Amuri form. The glauconitic base of the Amuri stone in the same area (5448) yielded a poorly preserved fauna containing *Rotaliatina sulcigera*, *Pseudogaudryina reussi*, *Hopkinsina bortotara*, *Marginulina hochstetteri*, *Cibicides parki*, and *Siphogenerina postprandia* (see below); this fauna is Lower Ototaran, i.e., Kaiatan. At Hurunui, the "Chalk Marls" under the Amuri stone already have an abundant Upper Bortonian fauna, so that the Grey Amuri limestone appears to be a compressed deposit filling the whole Ototaran sequence, from Kaiata to Cobden, the overlying Weka Pass stone being Duntroonian-Waitakian. The Hydraulic Limestone of Auckland and the Chalky Limestone of Poverty Bay, however, in spite of lithological similarity, have Wanstead faunas and correlate with the Amuri Chalk Marls.

Still more recent collections indicate clearly that in the typical Waipara Gorge area the sandy marl formation underlying the Amuri stone contains only Lower and Upper Bortonian faunas, while marly basal bands of the true stone yield *S. postprandia*, *Bolivina* cf. *reticulata* and *lapsus*, and other definite Ototaran species, while at the

Conway River mouth, close to the typefull exposure of the Amuri stone, the lower part of the limestone with flints is already Upper Bortonian. The Tertiary age of the whole deposit, even in its fullest development, is thus demonstrated, and backed by correlation evidence for the first time.

The species has been seen from the typical Duntroonian (5660; base of Duntroon limestone, with *Waiparia elliptica*), but not in the Wharekuri beds, Waitaki limestone, or Otiake beds. It is present at Kyeburn (G.S. 1903), at two localities in the lower Te Kuiti beds (5629, Orahiri S.D.; G.S. 526, Pirongia S.D., with mollusca like Wharekuri), just above the Cobden limestone (5363), in the basal Grey Marls (Weka Pass, East Grey, Motunau), and in the Dannevirke and Hawke's Bay "Lower Ihungian." These Waitakian-Lower Hutchinsonian specimens are often not exactly typical, but differ too slightly for any useful separation.

A shell very similar to *striatissima* is abundant in the Kaiatan of Kakanui (5307, lowest limestone, 85 chs. at 55° from Trig. V) and Cormacks (5182, just above diatomite), but is considerably stouter, with more convex chambers and less acicular form, the ribbing being much weaker, especially in the sutures; uniserial chambers about five, lower ones almost smooth, apical spikes and plates much feebler. It may be called *Siphogenerina postprandia* n.sp. (plate 13, figs. 40, 41), the holotype being from Cormacks and measuring 1 mm. by 0.2 mm. in size. There is a single not adult specimen in the Tahuian Burnside marl (5068), which seems closer to this species than to the Bortonian *prisca*, and another occurs in the Kaiatan of Swinburn S.D. (G.S. 2101). Three other forms derived from *striatissima* occur in beds above it and are now described.

***Siphogenerina rerensis* n.sp. (Plate 11, fig. 8.)**

1926. *Uvigerina tenuistriata* of Chapman; *N.Z.G.S. Pal. Bull.*, no. 11, pl. 14, fig. 9; *non* Reuss (Orakei Bay).

Shell generally similar to *striatissima* and of the same size, but with notably longer and fewer chambers. Those of *striatissima* are oblong, about half as high as wide, with almost straight sides; those of *rerensis* are two-thirds to three-quarters as high as wide, with markedly curved sides. There are never more than five, usually four, uniserial ones; the triserial part is much less hidden by sculpture, the *Uvigerine* chambers distinctly convex and noticeable, forming a somewhat bulbous apex to shell (about one quarter of total length). Ribs are very similar but more distant, about twice their width apart, produced into the same irregular spines posteriorly (though these tend to coalesce more into one long and strong spine), of even strength over whole shell, not diminishing on last chamber or base. Aperture relatively longer and wider, with a rim and one or two concentric ridges.

Length, 1 mm.; width, 0.2 mm.

Holotype from loc. 3029, Whangara Beach, South of Whangara, Poverty Bay, in argillaceous sandstone, above the lowest massive mudstone. Horizon, Hutchinsonian, i.e. Lower Miocene.

This sandstone is the local equivalent of the Rere formation, in which the species is common but usually imperfectly preserved. Another equivalent is the Waitemata horizon of Orakei (Hobson's) Bay; on Chapman's actual slide from this locality the specimens identified as *U. tenuistriata* are elongate forms of the *pigmea* line, but his figure obviously represents the *Siphogenerina* common there.

All the distinguishing features of this species are already to be seen in the specimens from the underlying "Pukahika" shale, which belongs faunally with the Ihungian, as part of the Hutchinsonian. It is also present in the Mahoenui beds, and there is one undoubted shell in 5197, 20 ft. below top of Mokau, Awakino River mouth, South side (with an accompanying fauna very like Ihungian); but I have seen no specimens from the Tutamoe or Awamoan elsewhere, and it is probably a good Hutchinsonian index fossil. In the South Island Hutchinsonian a closely related but distinct species replaces it; this has the same general separative features from *striatissima* in the distinct Uvigerine portion, regular and persistent ribbing and convex chambers, and differs from *rerensis* only in smaller size, still more distinct and convex chambers, the end ones tending to become globular and separated, and the more numerous finer and lower ribs, especially posteriorly, where the triserial part (about one third of length), instead of being more strongly and spikily sculptured is actually smoother, with the ribs twisting into a single terminal spike. This form may be called *Siphogenerina vesca* n.sp. (or variety) (plate 13, figs. 46, 47), the holotype being from locality 5105, Citrini's Area, near Kumara, Greymouth "Blue Bottom"; horizon, Hutchinsonian. The same species occurs also at loc. 5364, near Cobden village in a horizon below the true Blue Bottom, and above the Cobden, but is already replaced in a still lower horizon at the same locality (5363) (which is still 100 ft. above the Cobden) by *striatissima*, so that in this district the evolutionary line is plain. The species further occurs in the Burnside sandstone (5072, 6ft. above glauconite band) and Caversham sandstone (5092, with *Pachymagas*), but has nowhere occurred at any South Island Awamoan horizon with the exception of one doubtful shell from the Rifle Butts (5125A).

On the evidence, both *rerensis* and *vesca* seem to be characteristic Hutchinsonian species; both are related to the Trinidad Oligocene *multicostata* Cushman and Jarvis (see Cushman, 1929, p. 95, pl. 13, f. 38), especially the former, but have ribs interrupted much more by sutures, not continuous over shell.

***Siphogenerina pohana* n.sp.** (Plate 13, figs. 44, 45.)

Shell related to the previous species but smaller and with very fine sculpture. Triserial part distinct, slightly bulbous (about one fifth of total length), followed by 5 to 6 uniserial chambers about two-thirds to three-quarters as high as wide, lightly convex, sutures distinct but not deep, whole surface evenly covered with excessively fine and dense axials, not overrunning sutures as in the other species and visible only with a favourable light reflection. Apex with a very short single spine. Apertural tube relatively large and wide.

Length, 0.75 mm.; width, 0.12 mm.

Holotype from loc. 3099, Uawa Surv. Dist., Poverty Bay, just East of Trig. 166. Horizon, Poha formation = Taranakian, i.e. Upper Miocene.

This species is known mostly from the Poverty Bay area and is never common but has occurred in numerous samples, e.g. 2103, Waikaretaheke Rd.; 2128, Whaingake; 3137, 100 ft. above base of Poha, Kaiti Beach; and 5018 and 4151, directly below Otomahukua limestone, Hangaroa Stream, type Poha section. Its downward range is uncertain; it has not been seen in the Poverty Bay Tutamoe, but fine examples occur in 5630 (Owen road saddle, Totoro S.D., Taranaki) at a horizon which is certainly below Tongaporutu, and is either high in the Mokau or Mohakatino. In basal Mokau from the same area was one small specimen more like *rerensis*. The fauna of 5630 is closely similar to that of the South Island Jedburgh "Grey Marls" of the Cheviot district, where *S. pohana* also occurs (5558, 5560); no *Bolivinita* occurs, but the fauna is very like Taranakian and like other Jedburgh marls with *Bolivinita* (5557A).

***Siphogenerina prisca* n.sp.** (Plate 13, figs. 48-51.)

Shell small, with a disproportionately large triserial part, and few uniserial chambers, with inconspicuous ribs. Surface smooth and glossy between ribs, chambers inflated, especially the Uvigerine ones, separated by fairly deep sutures. Uniserial chambers usually only two, never more than three. Axial ribs thin and delicate, very little raised, numerous but several times their width apart, discontinuous across sutures, produced into little spikes on apex, subobsolete on uniserial chambers, absent on base, which rather flatly and narrowly truncates the globular last chamber, the aperture being a small rimmed tube in the depression. The whole impression is that of a juvenile *Uvigerina pigmea* with a couple of extra staggered cylindrical chambers.

Length, 0.6 mm.; width, 0.2 mm.

Holotype from topmost part of Hampden section (loc. 5179A, one mile North of Kakaho Creek), coll. by Professor Park. It is fairly common here, but almost absent elsewhere in the Hampden beds.

This was an interesting discovery, as the species had been known to me previously only as a very distinct form in the well-cores of Waitangi No. 1 Well, Poverty Bay, which correlate faunally with the surface Te Hua beds. In the well-cores it is present both above and below red bentonitic shales, so that this part of the section is certainly a correlative of the Bortonian. Neither the genus itself nor *Hopkinsina*, which is common in the well, is known from the Cretaceous; this supplies further evidence for regarding the surface outcrops of Upper Cretaceous red shale (with *Ezekakina*) as a distinct formation (see Finlay, 1939B, p. 536). In all other key species the well Te Hua beds correlate with the Bortonian, both Upper and Lower, and are undoubtedly Tertiary; these key species are absent from the surface outcrops, where the abundance of *Ezekakina* and *Bolivinita spectabilis*, etc., points strongly to the Rakauroa Cretaceous horizon.

Since the above was written, the species has been observed at three more localities—in the Dannevirke Waiwaka (5279, Motutaraia Surv. Dist.; with *Zeauvigerina zelandica* Finlay an index form of the Upper Bortonian; in the Motunau district (5635, Stoneyhurst S.D., chalk marl below hard Amuri stone); and in the East Grey area (5449, glauconitic quartz sands below the Amuri limestone). The latter occurrence is particularly interesting, as it occurs in a known section, the glauconitic base of the Amuri stone above (5448) having a Kaiatan fauna, while the grey clays below (5328) carry a good Lower Bortonian assemblage.

*S. prisca* thus seems to be an Upper Bortonian indicator of considerable value.

***Siphogenerina ongleyi* n.sp.** (Plate 13, figs. 42, 43.)

Shell large and stout, microspheric form strongly tapering posteriorly to a point, megalospheric form almost cylindrical with blunt apex, lower half of both forms subcylindrical, narrowly truncate below, the aperture being situated in a shallow crater exactly as in *prisca*. Triserial portion very large, occupying about two-thirds of shell length; the chambers moderately inflated and separated by deep sutures. Uniserial chambers two or three at most, considerably staggered; whole shell covered with fine, close, low but fairly prominent axials, about twice their width apart. They are very regular in direction, and are crossed by a shallow groove posteriorly on each chamber to form a slight infrasutural shoulder of short, blunt points. These project more prominently near apex, which has numerous small spines.

Length, 1 mm.; width, 0.25 mm. (microspheric). Megalospheric form reaches 0.8 mm.

Holotype from loc. 5093, Porangahau-Wimbleton Rd., Porangahau (S.E.) Surv. Dist.; coll. M. Ongley. This locality has exactly the same fauna as 1005, Taiporutu Stream, Mahia Peninsula; the exact field relationships and horizon of both are uncertain.

Except at these two localities the species occurs but rarely; nearly always in Ihungian faunas. It has been seen in the following: 3013, Whangara, mudstone below Tutamoe; 2093, Tunanui Creek; 2155, Hicks' Bay; and, in the Dannevirke area, 5347, Pourere Surv. Dist and 5380, Porangahau Surv. Dist.—all these are in the Ihungian, but the Kaiti Beach Upper Tutamoe localities 3132 and 3133 each have one specimen, so the range is apparently middle Ihungian-Tutamoe.

The species is very closely related to the Trinidad Eocene *Uvigerina seriata* Cushman and Jarvis (1929, p. 13, pl. 3, figs. 11, 12) (see also Cushman and Edwards, 1937, p. 82, pl. 12, figs. 9, 10), but this has a stouter aperture and seems to lack the infrasutural groove across the posterior points of the axials, which forms the shoulder effect in *ongleyi*. A form which better agrees with the New Zealand shell in these respects has been figured from the Burdigalian of

French Marocco (not ranging below this stage) by Lacoste and Rey (1938, p. 320, pl. 21, fig. 14). These forms are obviously of the same lineage as the Recent Hawaiian *irregularis* (Bagg); these species and *prisca* differ from the *striata* line in the basal depression surrounding the spout.

**Cassidulina arata** n.sp. (Plate 14, figs. 74, 75.)

Shell very small, in shape practically a miniature of *C. subglobosa*, and with the same aperture. Specifically characterised by the presence of distinctive sculpture, each chamber ploughed in direction of growth by fine and numerous irregular bifurcating furrows; the low ridges between are sometimes prominent on well-preserved shells, but are more often so inconspicuous that only a transverse illumination reveals them.

Major diameter, 0.3 mm.; minor diameter, 0.25 mm.

Holotype from Marsden "Blue Bottom" (5275).

This is a characteristic and important key species of the Hutchinsonian. When present it is often abundant, but easily overlooked as a juvenile of *subglobosa*, though the two specimens seldom occur together. It is widespread and has been seen often in the Poverty Bay middle Ihungian, the lower Mahoenui beds, the Waitemata beds, and the Greymouth "Blue Bottom." It has never occurred in the Upper Ihungia or Tutamoe, or in beds below the basal *Waiparia* bed of the middle Ihungian and is apparently a safe indicator of true Hutchinsonian age. It is interesting therefore that it also occurs at Pakaurangi Point (G.S. 1189, and in the *Miogypsina* band) and in the basal limestone at Clifden with type Hutchinsonian brachiopods.

**Cassidulina subglobosa** Brady.

1926. *Bulimina globocapitata* Chapman; *N.Z.G.S. Pal. Bull.*, no. 11, p. 38, pl. 8, figs. 16 a, b.

Chapman described his species as common in the Amuri limestone and possessing a "sharply tapering aboral series . . . strongly curved or twisted to one side." His actual slide contains three specimens so identified; all, as can be seen even from his figure, are fragments of *Cassidulina subglobosa* with pieces of hard matrix adherent—this matrix is the "aboral series."

The species ranges throughout the whole New Zealand Tertiary and into the Recent, but is not in the Cretaceous.

Family ROBERTINIDAE nov.

I propose this new family to contain the genera *Robertina* d'Orbigny, 1846, *Ceratobulimina* Toula, 1920, *Pseudobulimina* Earland, 1934, and the two new groups here proposed, *Ceratocancris* and *Cerobertina*, basing the family name, as should be done, on the earliest named genus it contains. The three already known genera are variously associated at the present time with families and genera to which they seem but little related. *Pseudobulimina* is so like *Ceratobulimina* in all but the series of supplementary chambers that it seems anomalous to refer the former to the *Cassidulinidae* and

the latter to the *Turriliniidae*, as lately done by Chapman and Parr (1937, p. 80); *Astrononion* remains in the *Nonionidae*, close to *Nonion* in all respects, except in the possession of similar supplementary chambers. Cushman (1933, p. 254) associates *Ceratobulimina* with *Pulvinulinella* in a sub-family Ceratobuliminidae of the Cassidulinidae, but this seems a very strange allocation, as the apertural characters are totally unlike, and neither much resembles the large and homogeneous Cassiduline group. Galloway (1933, p. 280) puts *Ceratobulimina* near *Cancris* and *Lamarckina* in the Rotaliinae, but places (page 368) *Robertina* with *Cassidulina*, while the more usually accepted location is near *Buliminella* in the Buliminidae. I can see little affinity between the aperture of *Robertina* and that of any of the forms legitimately referred to *Buliminella*. Compare, for example, the excellent figures of the species of *Robertina* given by Cushman and Parker (1936B, p. 92, pl. 16) with those of the Buliminellid forms from the Cretaceous (Cushman and Parker, 1936A, p. 5, pl. 2) and Tertiary (Cushman and Parker, 1937, p. 65, pls. 9, 10).

There is a very striking general similarity in structure, texture, and aperture in the five groups mentioned. The structure is a rather tightly wound spiral, varying from narrowly acute to flatly rounded, or laterally expanded; the texture is smooth and glossy, the shell wall usually thick and laminated; though frequently thin in the more primitive *Robertina*; the aperture is especially characterised by a simple deep slit in the terminal face. *Robertina* is described as having a supplementary smaller aperture at the junction of this face with previous chambers; this seems to represent the more or less prominent umbilicus seen in the other groups. A comparison of the figures of *Robertina charlottensis* (Cushman) (see Cushman and Parker, 1936B, pl. 16, fig. 12) and *Pseudobulimina chapmani* (Heron-Allen and Earland) (see Earland, 1934, pl. 6, fig. 11-14) makes it extremely difficult for one to deny the close relationship of these two micro-organisms; the secondary chambers are exactly the same in type and position. Earland noted (*l.c.*, p. 134) that these apparently constituted the only observable difference from *Ceratobulimina*, of which he had been "unable to find any with even a vestigial trace of the second series." I am describing below a genus of several species which again is extremely like *Ceratobulimina*, but has a definite series of secondary chambers on the umbilical instead of the dorsal side, and I have seen related Recent Indo-Pacific forms which, though very flat and almost *Nonion*-like, still show distinctly similar umbilical chamberlets.

As regards the systematic location of this group, I suggest that it is more likely derived from a Bulimine than a Rotalid ancestor, and that the resemblance to *Cancris*, *Valvulineria*, etc., is due to isomorphism. The Cassidulinidae as a whole have very similar texture and double chambering, and many species show a sort of double aperture, the principal cleft in the terminal face together with another at right angles along the parietal wall, not unlike the arrangement seen in *Robertina*. But the group as a whole has diverged

so far from *Cassidulina* and its immediate allies that it would seem best to erect for it a separate family following Bulminidae and Cassidulinidae.

In *Robertina* and *Pseudobulimina* there are secondary chamberlets along the suture on the dorsal side; *Robertina* is spirally elongate, higher than wide, *Pseudobulimina* is spirally depressed, wider than high. In *Cerobertina* there are secondary chamberlets along the umbilicus on the ventral side. In *Ceratobulimina* and *Ceratocancris* there are no secondary chamberlets, the former having an open *Robertina*-like apertural trench, the latter having an entirely covering plate, leaving a *Discorbis* or *Cancris*-like opening along the base of the last chamber from umbilicus to periphery.

In the abundant specimens I have studied the constancy of coil-direction, at least in *Ceratobulimina*, *Ceratocancris* and *Cerobertina*, is remarkable. In a dextral species no examples have been seen of sinistral individuals, or *vice versa*, and I would regard this as a specific feature. All the species seen have been dextral, with the exception of *Cerobertina tenuis* and *C. mahoenuica*.

#### Genus ROBERTINA d'Orbigny, 1846.

Genotype (monotype): *Robertina arctica* d'Orb.; *Foram. Foss. Bass. Tert. Vienne*, 1846, p. 202, pl. 21, figs. 37, 38 (Recent, Siberia).

Half a dozen species have been observed in the New Zealand Recent and Tertiary faunas, as far back as the Waiarekan (Lower Oligocene), where there is a species very similar to *R. ovigera* (Terquem) (see Cushman and Parker, 1936B, p. 98, pl. 16, figs. 15 a, b) but much larger, reaching 0.75 mm. in length, with less rapidly expanding chambers (there being about seven primary ones visible in front view, as against five in the Parisian form), and with the apertural slit running two-thirds of the way into the terminal face, instead of less than half. This may be known as *Robertina lornensis* n.sp (plate 12, figs. 27, 28), the holotype being from Lorne (5064), type Waiarekan; horizon, basal Kaiatan, i.e. Lowest Oligocene. The species has not occurred elsewhere. All other Tertiary examples observed so far have been very small and rare.

A species equally close in many respects is the German lower Oligocene *R. germanica* Cushman and Parker (1938, p. 73, pl. 16, fig. 2), which is as large, but has shallow sutures and narrower chambers.

#### Genus PSEUDOBULIMINA Earland, 1934.

Genotype (monotypic): *Bulimina chapmani* Heron-Allen and Earland; *British Antarct. Exped.*, 1922. "Terra Nova," Zool., vol. 6, no. 2, pt. 2, p. 130, pl. 4, figs. 18-20 (Recent, Antarctic).

No New Zealand records are known. Chapman and Parr (1937, p. 80) have lately noted that all records are from off the Ice Barrier.

## Genus CERATOBULIMINA Toulou, 1920.

Genotype (monotypic): *Rotalina contraria* Reuss; *Zeitschr. deutsch. geol. Ges.*, 1851, vol. 3, p. 76, pl. 5, fig. 37 (Oligocene, Germany).

Galloway's Manual gives the date of Toulou's work as 1915; I am unable to check it.

There seem to be more than one group included in the species discussed by Cushman and Harris (1927, p. 171–176, pl. 29). The forms represented by *C. hauerii* (d'Orbigny) with their plate-like extension completely covering the aperture are in New Zealand quite distinct from those of the *C. pacifica* Cushman and Harris type, in which the aperture is always perfectly open and is a much narrower slit; this aperture is not so well seen in the figure given by them as it is in Brady's (*Chall. Zool.*, vol. 9, p. 54, fig. 18). Forms resembling the variety *australis* of *C. hauerii* are not uncommon in New Zealand and perfect examples always show an unslit terminal face, the plate leaving merely a *Discorbis*-like aperture, but being noticeably thinner over a relatively wide medial tongue-like area, somewhat as in *Canceris*. No narrow slit is observable in these specimens. Only when broken do they show the tongue-like area open and inclined to one side of the terminal face. Individuals of the *pacifica* group never have a projecting plate even when fully adult. Shells at all stages show a deep, narrow slit extending straight into the terminal face for some distance. In both groups broken shells show that earlier chambers have the opening filled in from the umbilicus to leave only a sub-oval chink at the extremity of the tongue. This is less than halfway down the face in the *hauerii* type; more than halfway in *pacifica*. The faint groove on the terminal face seen in illustrations of the *hauerii* group apparently merely marks one side of the wide tongue, and is not the complete homologue of the *pacifica* furrow. The length of this feature seems to vary; in New Zealand, specimens of the former group always have it considerably shorter than those of the latter, but the Australian *hauerii* var. *australis* has it fairly long in the illustrations.

The presence at all, however, of a completely covering plate in some species, and its total absence in others, whose adults develop instead a normal deep and long cleft, is an apertural feature worthy of subgeneric status. The figures of Reuss's *contraria* show a long deep groove, without covering plate, so that the new group must be for the other type.

***Ceratobulimina* (s.str.) *kellumi* n.sp.** (Plate 13, fig. 60.)

Shell at least one and a half times as long as broad, compact, very inflated, elongate-globular, with no pronounced angles; six chambers in last whorl. Sutures distinct, practically flush with surface, usually markedly limbate, depressed into short furrows near umbilicus, which is practically closed. Aperture a very deep, narrow, entirely open furrow, extending from umbilical area two-thirds of distance into terminal face, slightly sigmoid, about one-fifth width of face. Dorsal surface tightly coiled, smoothly and evenly rounded; earlier chambers forming an almost flat top, spiral suture distinct but not sunken.

Length, 0.65 mm.; width, 0.45 mm.

Holotype from locality 4270, Tangihanga, Waikohu Surv. District, Poverty Bay. Horizon, Ihungian, i.e. Hutchinsonian, close to Awamoan.

Quite a number of perfect specimens in all stages occurred here and no trace of a covering plate is ever developed. Also common at 3029, Ihungian sandstone, Whangara beach, and at G.S. 1342, Waikura Stream (Tutamoe). In the definite Tutamoe, i.e. Awamoan, it occurs at G.S. 1296, Muddy Creek, is common at 1186 (Avondale Station) and 1195 (Te Aroha Stream), and continues into the Taranakian (3137, Kaiti Beach, and 4256, Ngatapa, both Poha formation). All these localities are in Poverty Bay, and so far the species has not often been seen elsewhere, nor in company with the previous one; that it has a longer range is evident from the occurrence of a few typical examples in the Waitakian of McClay's Farm, Otama Valley, Southland (G.S. 1909) and one in equivalent beds at Waikaia (5387).

It is named after Dr. L. B. Kellum, Chief Geologist of the New Zealand Petroleum Company, at present working in this area.

***Ceratobulimina* (s.str.) *lornensis* n.sp.** (Plate 13, fig. 61.)

Shell sub-circular, almost as broad as long; last chamber somewhat projecting, considerably inflated, not compressed. Six chambers in last whorl, progressively more separated as growth proceeds so that sutures become deeper and periphery more lobulate anteriorly; last chamber irregularly bulbous, with a rounded or slightly flattened terminal face into which projects for one third to half its length a narrow, not very deep, apertural furrow. Umbilicus widely open, about a quarter of width of shell, overlapped for half its width by free margin of last chamber before it joins previous whorl. Dorsal side with the radial sutures of last three chambers distinct, all others obscure. No ornament, surface smooth.

Length, 0.75 mm.; width, 0.65 mm.

Holotype from Lorne (5064), type of Waiarekan. Horizon basal Kaiatan, i.e. Lowest Oligocene. Not known from any other locality.

In its flattish sub-circular shell this differs conspicuously from the Miocene *kellumi*, and can be compared with the American Lower Eocene *C. perplexa* (Plummer). The figures of this species given by Cushman and Harris (*l.c.*, page 173, pl. 29, figs. 2 a-c), show that it is considerably more compressed vertically, giving it an acutely instead of bluntly rounded periphery. It has a similar short apertural cleft and open umbilicus less encroached on, however, by final chamber, and has conspicuous sutural ornamentation on the dorsal side. A species with even closer affinity is the recently described *C. westraliensis* Parr (1938, p. 83, pl. 2, figs. 12 a-c). This is a common species in the Upper Eocene of Western Australia and was also compared with *perplexa*; the figures show it to be of similar

inflation but with a still more extensive umbilicus and aperture notch and with chambers more numerous and more distinctly marked off. It is interesting that these three similar forms should all be from the Lower Tertiary.

### Subgenus CERATOCANCERIS NOV.

Genotype: *Ceratobulimina (Ceratocanceris) clifdenensis* n.sp.  
(Lower Miocene, New Zealand).

The separative features from *Ceratobulimina* s.str. are only in the aperture, and have been discussed above. Without seeing specimens I am unable to locate all the species discussed by Cushman and Harris, but the group contains the Miocene *C. haueri* (d'Orb.) (Europe), the Lower Miocene *C. australis* Cushman and Harris (Australia) and probably the Eocene *C. eximia* (Rzehak) (Europe and America). *C. alazanensis* Cushman and Harris would seem from the original figure to be not unlike *eximia*, but the later much fuller figures of Coryell and Embich (1937, p. 302, pl. 43, figs. 8 a, b) show plainly that it is a true *Ceratobulimina*, quite close to *kellumi*.

### *Ceratobulimina (Ceratocanceris) clifdenensis* n.sp. Plate 13, fig. 62.)

This is so closely related to the Australian *C. australis* that it is best described by comparison. I have only broken specimens of the latter from Muddy Creek, but they agree with the good figures given by the original authors and later by Chapman, Parr and Collins (1934, p. 559, pl. 10, figs. 26 a-c). These show that the Balcombian species has a notably longer furrow (and probably corresponding tongue), a more rounded and inflated terminal face, and a less involute coiling on the dorsal side. In New Zealand shells the furrow is extremely faint, and it and the tongue reach only one-third of the way into the face; this is very markedly and sharply flattened off at an acute angle with the basal periphery, which is thus more sharply bevelled than in *australis*; dorsally the chambers expand rapidly, the initial coils being very small. There are seven chambers visible ventrally as in *australis*.

Length, 0.7 mm.; width, 0.5 mm.

Holotype from Clifden, Southland, band 5 (5132); not uncommon (also in 6B). Horizon, just above Hutchinsonian, but below Awamoan.

This has a widespread distribution. Other Hutchinsonian localities at which it is present are Marsden "Blue Bottom"; Mahoenui beds (especially the lower part); Pakaurangi Pt. (several samples); Poverty Bay Ihungia beds of Muddy Creek (G.S. 1237 and "d-sandstone") and of Island Creek (G.S. 1262, 1240). In specimens from the last locality and from 5241 (Takapau, Ihungian) the shells are small, somewhat more inflated, and the ventral sutures tend to become limbate, though not raised. Limbation is much more a feature of *kellumi*.

Outside of this horizon it is extremely rare, and I have only one undoubted specimen from Awamoa Creek, type Awamoan (5124). It has not been seen in the Mokau, nor in G.S. 1342 (Waikura Stream, just at the Tutamoe boundary), a Tutamoe locality with very similar lithology to the Ihungian; but it does occur in G.S. 1259 and G.S. 1262, both 150–200 ft. above base of Tutamoe in Island Creek, and both very similar to the Ihungian in their foraminiferal and also molluscan faunas. The usual Tutamoe and Mokau form is *kellumi*.

#### Genus CEROBERTINA nov.

Genotype: *Cerobertina bartrumi* n.sp. (Lower Miocene, New Zealand).

Shell formation very similar to *Ceratobulimina*, with the same gloss, coiling and furrow-aperture, but with a series of supplementary chambers along the umbilical edge of the main chambers, more or less distinctly marked off by a groove or internal line.

Quite a number of species of this group are known to me, falling into three lines in New Zealand Tertiary history, while still other lines have been seen in Recent faunas from the Malay Archipelago.

A Recent species, almost certainly congeneric, has been described from Samoa; the figure of *Pulvinulina mayori* Cushman (1924, p. 41, pl. 13, fig. 6) shows distinctly the same shell formation, secondary chambers and slit aperture. When such forms become more symmetrically coiled, it is not long before almost an isomorph of *Nonion* is reached; three distinct species I have from Malay Archipelago show a regular transition from a very flattened but typical *Cerobertina*, through a glassy *Anomalina*-like species with very tiny umbilical secondary chambers, to finally an almost symmetrical form with the secondary chambers entirely enclosed within the main ones but distinctly visible in broken shells—this last form has been named *Nonion translucens* by Cushman (*U.S. Nat. Mus. Bull.* 161, pt. 2, p. 45, pl. 11, figs. 2 a, b, c; 1933).

Two Austral species of the group have already been described, *Bulimina convoluta* var. *dehiscens* Heron-Allen and Earland (1924, p. 143, pl. 8, fig. 26–28. Miocene) and *Ceratobulimina tenuis* Chapman and Parr (1937, p. 80, pl. 7, figs. 11 a, b. Recent). In both these species the secondary chambers can be easily overlooked, but are distinct on close examination.

It is to be noted that the original description of *dehiscens* refers to two sets of chambers, of which "the inferior or smaller series of chambers is entirely invisible when the specimen is viewed from the dorsal aspect."

*Cerobertina bartrumi* n.sp. (Plate 11, figs. 2, 3.)

Shell small, elongate, flattened (but still slightly rounded) ventrally, broadly convex dorsally, the convexity being greatest on periphery, which on last chamber becomes rather acutely bevelled. About eight chambers visible ventrally, the suture lines (which are quite inconspicuous, flush with surface and marked only by whitish bands) showing a regular downward dorsal sweep from initial

coil to periphery, where they gently curve up on to the ventral side; here at a distance a little less than height of chambers from periphery they meet a similar curving white band which terminates main chambers. The radial sutures swing slightly upwards past this into umbilical cleft, whose margin on that side is lobulated by the ends of these secondary chamberlets. Terminal chamber ventrally forms a long, narrow strip reaching up to threequarters of shell length, widening anteriorly and swinging round sharply to end in a well-marked angulation, whose summit joins the white band dividing the two sets of chambers; in its lower part a small deep cleft in direction of coiling penetrates terminal face for about half its length. For a little distance to the side of this and for a long vertical distance the space between secondary chambers and last main chamber is occupied by a deep umbilical cleft about equal to width of terminal strip alongside it. In ventral aspect the outline of outer edge is a rapidly unwinding spiral, the inner edge being straight or very slightly convex.

Length, 0.4 mm.; width, 0.2 mm.

Holotype from Pakaurangi Point, G.S. locality 1181. Horizon Waitematan, i.e. Hutchinsonian (Lower Miocene). Abundant in several samples from this locality, but not known elsewhere. Named after Professor J. Bartrum, of Auckland, who has sent me Pakurangi material.

This species is evidently the New Zealand representative of *C. dehiscens* (Heron-Allen and Earland). The Australian species is easily separated by its much more acutely rounded and laterally projecting apical portion, by its tendency to flare out to a greatest width anteriorly, and by the sharply pointed ending of the terminal chamber outer strip, which seems to swing laterally almost under the apical chambers instead of forming a flatly rounded ending in front of them. The ventral view of *dehiscens* shows the outer edge markedly convex. These differences are borne out both by Cushman and Harris's and the original figures, and by actual Muddy Creek specimens.

***Cerobertina tenuis* (Chapman and Parr).** (Plate 11, figs. 4, 5.)

1937. *Ceratobulimina tenuis* Chapman and Parr; *Aust. Antarct. Exped.*, Ser. C, vol. 1, pt. 2, p. 80, pl. 7, figs. 11 a, b.

This was described from 1320 fathoms in the Antarctic, lat. 42° 38½', long. 48° 41½'. I have one specimen (fig. 5) reaching 0.4 mm. from off Stewart Island, and two smaller and narrower ones from 6 fathoms Enderby Island (fig. 4), which I am unable to separate on the basis of the Australian figure and description. With all features noted by the authors the New Zealand specimens agree.

***Cerobertina mahoenuica* n.sp.** (Plate 13, fig. 58.)

Shell elongate, comparatively large, flattened ventrally, very convex dorsally. In features of shell structure like *bartrumi* but, because of convexity, the spiral tendency is much more pronounced and the consequent resemblance to a *Robertina* with a depressed spire

heightened. Eight chambers visible ventrally, all dorsal sutures inconspicuous, last three ventral sutures distinctly grooved. Secondary chamberlets very much more distinct than in *bartrumi*, marked off by a definite very undulating groove; increasing in size with growth (much more rapidly than main chambers), the final one appearing like a triangular swollen pustule in centre of shell, filling much of umbilicus; earlier ones rapidly becoming indistinct, usually no more than three visible altogether. Details of terminal face and aperture much as in *bartrumi* except that outer strip of last chamber is much shorter and widens rapidly, the umbilical cleft between it and chamberlets, though very deep, being shorter, about one third of shell length or less, and inclined at  $30^\circ$  when shell is vertical; in *bartrumi* cleft is almost vertical and about half length of shell.

Length, 0.8 mm.; width, 0.5 mm.

Holotype from Mahoenui beds (5576, 10 ft. below Mokau,  $\frac{1}{4}$  mile East of tunnel), head of Awakino Gorge. Horizon, Hutchinsonian (Lower Miocene).

The species is not uncommon in lower Mahoenui beds, but well preserved specimens are rare. It also occurs at Pakaurangi Point; Hobson's Bay, Waitemata beds; and in the Marsden "Blue Bottom" (5274). It seems to range somewhat higher, for good specimens occur in the Awamoan of All Day Bay (5273), but it has not been found elsewhere in the Awamoan.

***Cerobertina kakahoica* n.sp.** (Plate 13, fig. 59.)

Shell ancestral and very similar to *C. mahoenuica*. It is considerably smaller, half to two-thirds the size, relatively wider and with less tendency to elongate, the terminal chamber especially being semicircular instead of drawn out and its outer strip consequently hardly at all narrowly produced, the junction line with previous chamber being almost straight. The aperture is shorter and wider, appearing more like a triangular notch ending in a sharp point. Terminal face flat over whole area, instead of convex on outer peripheral side of aperture. Secondary chamberlets considerably reduced in size—all but last one practically obscured, so that the most marked feature is a single small circular pustule immediately above aperture notch.

Length, 0.5 mm.; width, 0.4 mm.

Holotype from locality 5179B, Kakaho Blue Clays,  $1\frac{1}{4}$  miles North of Kakaho Creek, Hampden Beach. Horizon, Upper Bortonian (Middle Eocene). This species usually occurs in Hampden samples, though never commonly; it is also in the Lower Bortonian there (5180). It has not so far occurred in the equivalent Wanstead of Hawke's Bay and Te Hua beds of Poverty Bay, but it does range into the Tahuian (extreme top of Hampden section, and also 4401, McCulloghs Bridge) and even Ototaran. It is not actually in the Waiarekan of Lorne, nor in the Oamaru limestones, probably because of facies, but in the lower Point Elizabeth beds (5354, 2171), which belong faunally with the Kaiata mudstone in the Kaiatan, there are examples, slightly larger than Hampden ones, but otherwise quite

typical, showing especially the one to two tiny rounded pustular chamberlets, instead of the large ones of the Miocene. Crushed specimens also occur in the Whaingaroa beds (5231, Waitetuna estuary), so that the known range is Lower Bortonian—Whaingaroan. All these specimens are dextral, while the Miocene *mahoenuica* is sinistral.

***Cerobertina crepidula* n.sp.** (Plate 11, fig. 1.)

Shell sub-triangular, anteriorly regularly rounded, thence narrowing apically to a blunt point, ventrally perfectly flat or slightly concave, the terminal chamber nearly always broken, but when present nearly semicircular, as in *kakahoica*, but occupying more than half of the surface; its surface is shallowly hollowed below the aperture, and above it there is a sudden drop in level. The whole of this surface is bounded by a narrow blunt rim, forming the periphery. Dorsally the chambers and sutures are very ill-defined. Ventrally about nine are visible, the obscure sutures crossing the space above last chamber sub-horizontally at narrow intervals, the length of each strip about four to five times height. Secondary chamberlets cannot be resolved but are probably present. The chambered side encroaches so much on the long slit-like umbilical area that the secondary chamberlets are probably folded under and hidden. The aperture is an extremely narrow deep cleft in direct line with the linear umbilicus, extending about halfway across terminal face. The shell is nearly always broken, revealing merely an open chink near dorsal edge of terminal face.

Length, 0.5 mm.; width, 0.4 mm.

Holotype from Clifden, Southland, Band 5 (5132). It occurs also in 6B and rather commonly in 6C, all being horizons just above Hutchinsonian and below Awamoan.

It has been met with, usually rarely, in numerous samples from all over New Zealand, but has never been seen outside of the Hutchinsonian and Awamoan. Other Hutchinsonian occurrences are Grey-mouth "Blue Bottom" (5088, 2182); Pakaurangi Pt.; and Terakohe Quarry, Takaka (5056). Some Awamoan localities are All Day Bay; Goodwood series, Moeraki (5259); lower Tutamoe beds, Poverty Bay (G.S. 1259, G.S. 1342); Tunanui beds,  $\frac{1}{2}$  mile from mouth of Tutae-matuatua Creek (2047).

This is a somewhat anomalous species and the non-visibility of secondary chambers makes its definite reference to *Cerobertina* a little doubtful, but it is extremely like the other species in all other features.

***Eponides lornensis* Finlay.** (Plate 13, figs. 52, 53.)

1938. *Ibid.*, Finlay, *Trans. Roy. Soc. N.Z.*, vol. 68, pt. 1, p. 522.

The holotype and paratype are here illustrated. This species also occurs at 5244 (Bridge Point) and 5243 (Rifle Butts conglomerate under limestone), both coastal South Island Kaiatan horizons. It seems limited to such very shallow water deposits, and does not occur in the Kaiata-Cobden area except in the basal bed which is

equivalent to Lorne. Nor has any member of the group been seen in the Whaingaroan elsewhere, so that the change from *lornensis* to *repandus* cannot yet be vertically localised.

***Oibicides tholus* n.sp.** (Plate 12, figs. 34, 35.)

Shell fairly small, hemispherical, of coarse texture, heavily sculptured dorsally, almost smooth ventrally; about 11 chambers per whorl, visible on both sides; dorsally not quite as long as wide; dorsal surface very coarsely punctate, with heavy, close papillae covering the inner whorls, surrounded by an equally heavy, nodular spiral ridge marking the inner rim of last whorl. The ridge ends before last two or three chambers and from the nodules narrow limbations proceed radially halfway out along each suture. Between the papillae ridge, and limbations are various deep grooves and pits. Ventrally almost smooth, an area on periphery and halfway down base quite smooth and almost free of punctae. Lower part of base with coarse but inconspicuous perforations, especially along the faint suture lines; no umbilicus; completely involute. Apertural face flat, smoothly rounded at joint with base and dorsal surface, where it rises considerably above peripheral subangulation; aperture a narrow, convex slit, with a distinct rim, equally spread for a short distance below and above angulations, and extending back dorsally for two or three chambers in the usual generic fashion. Dorsal outline practically flat; basal outline almost a perfect semicircle.

Diameter, 0.7 mm.

Holotype from near Waihiriri, Block 14, Waimata Surv. Dist., Poverty Bay (3294); this is a Te Hua equivalent, with *Zeauvigerina*. Horizon, Upper Bortonian, i.e. Middle Eocene.

This is a highly characteristic species of the Bortonian and occurs in the type Wanstead (5371) and the Waitangi No. 1 well-cores, and is one of the few Bortonian key species present also in the Poverty Bay Chalky Limestone (4008), wherever it is associated with Te Hua marls (in which *tholus* also occurs). It appears to be limited to Upper Bortonian of the North Island, for it has not been seen at Hampden or elsewhere in the South Island. It seems to be fairly closely related to *C. grimsdalei* Nuttall (1930, p. 291, pl. 25, figs. 7, 8, 11), restricted to the Mexican Lower Eocene, but has heavier dorsal sculpture and more evenly convex base. The later figure of this species from French Morocco by Ostrowsky (1938; p. 353, pl. 24, figs. 1 a-c) is less like the New Zealand shell, and has more sinuous ventral sutures.

**Genus BUNINGIA nov.**

Genotype: *B. creeki* n.sp.

This is proposed for a new group of the Rotaliidae. As no species but the genotype is at present known, the generic characters and affinities depend on that species, and are discussed in its description.

**Bünigia creeki** n.gen., n.sp. (Plate 14, figs. 82-84.)

Shell small, very inflated; dorsally flattened and vitreous, with a peripheral rim, deeply umbilicate, not quite involute; ventrally deep and globose, no umbilicus, quite involute; aperture entirely dorsal, a horizontal opening at side of umbilicus. Chambers five per whorl, very globose basally and at side, flattened on top; sutures inconspicuous, not limbate, marked only by shallow grooves; meeting on base (at a point off centre and nearest to aperture) in a shallow lateral depression but no umbilicus. Whole of base and two-thirds up side finely and evenly perforate; upper third of periphery marked by a low wide swelling forming a very blunt keel with a shallow groove between it and test below; this sub-keel has the pores obsolete or absent, giving it a translucent or vitreous appearance in sharp contrast to rest of shell; dorsally it is perfectly flat, truncating the shell, and is about as wide as the umbilicus. The latter is a wide deep pit corrugated inside by the chambers whose sutures there become deeper; the flat area rounds off evenly into umbilicus, except at last chamber where there is a sharp, thin curved lip, marking entrance to the low horizontal aperture; the opening of this is not visible from above and only partly in side view, being considerably hidden by and merging with the sunken umbilical opening. Contact of last chamber with rest of shell quite even and gradational from base to just inside the sub-keel dorsally, then immediately free as the aperture lip; on periphery at lower edge of sub-keel this contact is pushed back, the chamber running slightly forwards both above and below; a deeper translucency is sometimes visible here, but there is no opening.

Major diameter, 0.37 mm.; minor diameter, 0.31 mm.; height, 0.23 mm.

Holotype from Marsden "Blue Bottom" (5275), 6 miles South of Greymouth, 4 miles East from sea coast. Horizon, Hutchinsonian, i.e. Lower Miocene.

This is apparently a characteristic and restricted species of the Hutchinsonian. It is quite common in the "Blue Bottom," but easily overlooked on account of small size and resemblance to *Globigerina*. In the Cobden area it has not been seen below the typical "Blue Bottom," being absent in the "grading beds" (5363, 5364) above the limestone. In West Grey Stream it is present in sandy mudstone above (5262) and below (5263) the narrow band of brachiopod limestone, which is thus an intra-Hutchinsonian formation. It has not been seen in the Weka Pass Grey Marls (G.S. 71), nor the All Day Bay basal and lower greensands, nor at Takaka or Clifden, but is in the Trelissick Basin tuffs (5054, below limestone, Porter and Thomas Rivers); it has occurred several times in the Māhoenui beds, especially the lower part, and is present in the Ihungian beds of Dannevirke area (5347, Pourere Surv. Dist.) and Poverty Bay (5390, Rotokautuku Creek; 5389, Mangaoporo River, etc.), and also in the Lower Ihungian (Pukahika) shales of the same district (5394).

The affinities of this form are doubtful. It is not like anything else so far seen in New Zealand, where various forms of *Anomalina*, *Valvulineria* and *Discorbis* commonly occur and, as I cannot relate it to any species seen in literature, it is here made the type of a new genus. There is at first sight some relationship to certain species of *Valvulineria*, e.g. the Californian Eocene *V. involuta* Cushman and Dusenbury, and the Miocene *V. casitasensis* Cushman and Laiming, but these seem to grade into forms such as *araucana* (d'Orbigny) and *californica* Cushman, the genotype. The last-named, which must be the real criterion in judging affinity, is not in the least like *creeki*, which shows a complete reversal of dorsal and ventral sides (and corresponding aperture) and could be considered a *Valvulineria* derivative only if wrongly orientated and widely aberrant in its dorsal involution and absence of umbilical pad.

There is more possibility that the New Zealand form is connected with *Discorbis*, especially some of the small globular types with funnel aperture, such as the Australian Tertiary *inflata* and *globigeriniformis* Heron-Allen and Earland (1924, pp. 171, 172), but in this "*pulvinata*" group the aperture has become very distinctive and again could not be closely compared with *creeki*, unless the orientation were reversed.

There are not many genera with dorsal apertures. *Anomalina* is stated by Galloway (1933, p. 287) to be involute on the side opposite the aperture, but *creeki* is not like the genotype and other species usually placed there. By far the most affinity seems to be with the *Cibicidinae*, and *Büningia* can readily be visualised as an extreme development of the *lobatulus* type, in which the aperture has simply migrated entirely to the dorsal side (where more than half of it already is in some species) and become hidden by lateral crowding in of the last coil. Such a simple species as the Western Australian Eocene *Cibicides pseudoconvexus* Parr (1938, p. 86, pl. 3, figs. 5 a-c) has already begun this migration and has approximately the same habit of shell; specimens quite close to the latter species are very common in the New Zealand Ototaran and show this sort of development quite plainly. An allied form is *Karrerria* Rzehak; authentic specimens show that this is another separable group also derived from a simple type of *Cibicides*; German examples from the Cretaceous of Maderberg show a mostly dorsal aperture, but not terminal as stated by Galloway.

The genus name is given in honour of Dr. W. L. Büning, micropalaeontologist of the Shell Oil Company, who independently found this form in Mahoenui beds. The specific name given is that of Dr. C. W. Creek, Chief Geologist in New Zealand for the same company.

#### Genus GLOBIGERINOIDES Cushman, 1927.

The usual association of *conglobata* Brady, *sacculifera* Brady, and *rubra* d'Orbigny (the genotype) is commonly found in Recent gatherings from New Zealand, and the last two extend back into the Waitotaran (e.g. 5408, Wairoa silts between Whakake and Nuhaka) but not earlier. The genus seems to be completely absent throughout the Middle Tertiary and does not reappear until the Lower Ototaran

or Kaiatan is reached. From this horizon down into Upper Bortonian (i.e. Lower Oligocene to Mid. Eocene) a distinct species, which may be called *Globigerinoides index* n.sp. (plate 14, figs. 85-88), occurs in great abundance and becomes the dominant Globigerinid. From *conglobata* it is separable at sight in its fewer and regularly inflated, instead of flatly rounded, chambers and its totally different apertural system, each chamber having instead of the several tiny openings of *conglobata* one very large and widely gaping final opening and two others somewhat smaller above the sutures of previous chambers. The two species are similar in their deeply cleft sutures and robust shell walls. There is a slight resemblance to a Mexican Eocene form figured by Nuttall (1930, p. 290, pl. 24, figs. 12, 15), which he compared with *orbiformis* Cole. The latter species has been recorded from the West Australian Eocene by Parr (1938, p. 87, pl. 3, figs. 7 a, c), who quotes Thalmann's consideration of it as synonymous with *Globigerinoides mexicana* (Cush.); all these forms are more tightly coiled and have more chambers than the New Zealand form.

This is an important key species of Upper Bortonian to Kaiatan time, its ubiquitous nature and constancy within that range and easy determination increasing its usefulness. It is the only *Globigerinoides* in the New Zealand early Tertiary and, though abundant in the Lower Otataran Oamaru limestones and Kaiata beds, has vanished completely from the overlying Whaingaroan, where *Globigerina angipora* Stache is quite dominant and equally abundant. It is not to be confused with a small subspherical *Globorotalia* (aff. *dehiscens* Chapman, Parr and Collins), which ranges through Bortonian. In the Lower Bortonian the latter is accompanied by another very distinct *Globorotalia*, which is like *aragonensis* Nuttall (1930, p. 288, pl. 24, figs. 6-8, 10, 11) but has only 4-5 chambers per whorl, a sharp keel, and a practically flat top. This may be called *Globorotalia crater* n.sp.; the holotype is from 5570 (Chalk Marls, below Amuri stone, Hurunui River,  $\frac{1}{2}$  m. S.W. of Trig. B); it has been met with in many localities throughout New Zealand, but never above the Lower Bortonian, of which it may be regarded as the index fossil.

Abundant in Bortonian and reaching Whangai below and Kaiata just above is a true *Globigerina* of the *bulloides-triloba* type, which is easily distinguished from the more typical forms in later horizons by a slight flattening and compression of each chamber and especially by its wide but very low and hardly open aperture directed laterally to overhang a previous chamber, instead of centrally, and with a pronounced rim. This may be called *Globigerina linaperta* n.sp. (plate 13, figs. 54-57). The holotypes of both these forms are from the Hampden section (5179A, beach 1 mile North of Kakaho Creek); here *index* reaches a diameter of 0.4 mm. and *linaperta* of 0.38 mm., but both have been seen larger elsewhere. Especially characteristic of the Upper Bortonian is a variety of *linaperta*, which reaches a much larger size, has swollen chambers, and a strong tendency to cover the aperture with a supplementary small, smooth chamber; this may be called var. *turgida* nov., the type being from 3310, Pahi marl.

## LIST OF NEW NAMES PROPOSED.

(For European age-equivalents here used, see Finlay, 1939, p. 531.)

## FAMILY.

Robertinidae n.fam. for *Robertina*, *Ceratobulimina*, *Pseudobulimina*, *Ceratocancris* and *Cerobertina*.

## GENERA.

- Arenodosaria* n.gen. (Fam. Valvulinidae). Genotype: *Clavulina robusta* Stache (Eocene-Miocene, perhaps Recent).  
*Ceratocancris* n.subgen. (Fam. Robertinidae). Genotype: *Ceratobulimina* (*Ceratocancris*) *clifdenensis* n.sp. (Lower Miocene).  
*Cerobertina* n.gen. (Fam. Robertinidae). Genotype: *C. bartrum* n.sp. (Eocene-Miocene, Recent in Pacific).  
*Büningia* n.gen. (Fam. Rotaliidae). Genotype: *B. creeki* n.sp. (Lower Miocene).

## SPECIES.

- Textularia zeaggluta* n.sp. (5371, Bortonian). Middle Eocene.  
 „ *cuspsis* n.sp. (5182, Kaiatan). Lower Oligocene.  
 „ *marsdeni* n.sp. (5274, Hutchinsonian). Lower Miocene.  
*Siphotextularia awamoana* n.sp. (5124, Awamoan). Middle Miocene.  
*Verneulina browni* n.sp. (5181, Whaingaroan). Middle Oligocene.  
*Gaudryina fenestrata* n.sp. (5274, Hutchinsonian). Lower Miocene.  
*Clavulinoides olssoni* n.sp. (5390, Hutchinsonian). Lower Miocene.  
 „ *instar* n.sp. (G.S. 1342, Awamoan). Middle Miocene.  
 „ *virilis* n.sp. (5373, Whaingaroan). Middle Oligocene.  
*Listerella weymouthi* n.sp. (3089, Awamoan). Middle Miocene.  
 „ *levis* n.sp. (5371, Bortonian). Middle Eocene.  
*Tritaxilina zelandica* n.sp. (5358, Whaingaroan). Middle Oligocene.  
 „ *languida* n.sp. (5279, Bortonian). Middle Eocene.  
*Bolivina lapsus* n.sp. (G.S. 1189, Hutchinsonian). Lower Miocene.  
*Plectofrondicularia pellucida* n.sp. (5207, Opoitian). Lowest Pliocene.  
 „ *awamoana* n.sp. (5273, Awamoan). Middle Miocene.  
*Bulimina bortonica* n.sp. (5179B, Bortonian). Middle Eocene.  
*Uvigerina miozea* n.sp. (5389, Hutchinsonian). Lower Miocene.  
 „ *dorreeni* n.sp. (5363, Waitakian). Upper Oligocene.  
 „ *paeneteres* n.sp. (3132, Awamoan). Middle Miocene.  
 „ *mioschwageri* n.sp. (G.S. 1342, Awamoan). Middle Miocene.  
*Hopkinsina bortotara* n.sp. (5068, Tahuian). Upper Eocene.  
 „ *wanzea* n.sp. (5371, Bortonian). Middle Eocene.  
 „ *notohispida* n.sp. (4141, Taranakian). Upper Miocene.  
*Siphogenerina postprandia* n.sp. (5182, Kaiatan). Lower Oligocene.  
 „ *rerensis* n.sp. (3029, Hutchinsonian). Lower Miocene.  
 „ *vesca* n.sp. (5105, Hutchinsonian). Lower Miocene.

- Siphogenerina pohana* n.sp. (3099, Taranakian). Upper Miocene.  
 „ *prisca* n.sp. (5179A, Bortonian). Middle Miocene.  
 „ *ongleyi* n.sp. (5093, Hutchinsonian). Lower Miocene.  
*Cassidulina arata* n.sp. (5275, Hutchinsonian). Lower Miocene.  
*Robertina lornensis* n.sp. (5064, Kaiatan). Lower Oligocene.  
*Ceratobulimina kellumi* n.sp. (4270, Hutchinsonian). Lower Miocene.  
 „ *lornensis* n.sp. (5064, Kaiatan). Lower Oligocene.  
 „ (*Ceratocancris*) *clifdenensis* n.sp. (5132, Hutchinsonian). Lower Miocene.  
*Cerobertina bartrumi* n.sp. (G.S. 1181, Hutchinsonian). Lower Miocene.  
 „ *mahoenuica* n.sp. (5576, Hutchinsonian). Lower Miocene.  
 „ *kakahoica* n.sp. (5179B, Bortonian). Middle Eocene.  
 „ *crepidula* n.sp. (5132, Hutchinsonian). Lower Miocene.  
*Elphidium hampdenensis* n.sp. (5540, Lower Bortonian). Middle Eocene.  
 „ *saginaturn* n.sp. (5459, Upper Bortonian). Middle Eocene.  
*Büningia creeki* n.sp. (5275, Hutchinsonian). Lower Miocene.  
*Cibicides tholus* n.sp. (3293, Bortonian). Middle Eocene.  
*Globigerinoides index* n.sp. (5179A, Bortonian). Middle Eocene.  
*Globigerina linaperta* n.sp. (5179A, Bortonian). Middle Eocene.  
*Globorotalia crater* n.sp. (5570, Lower Bortonian). Middle Eocene.

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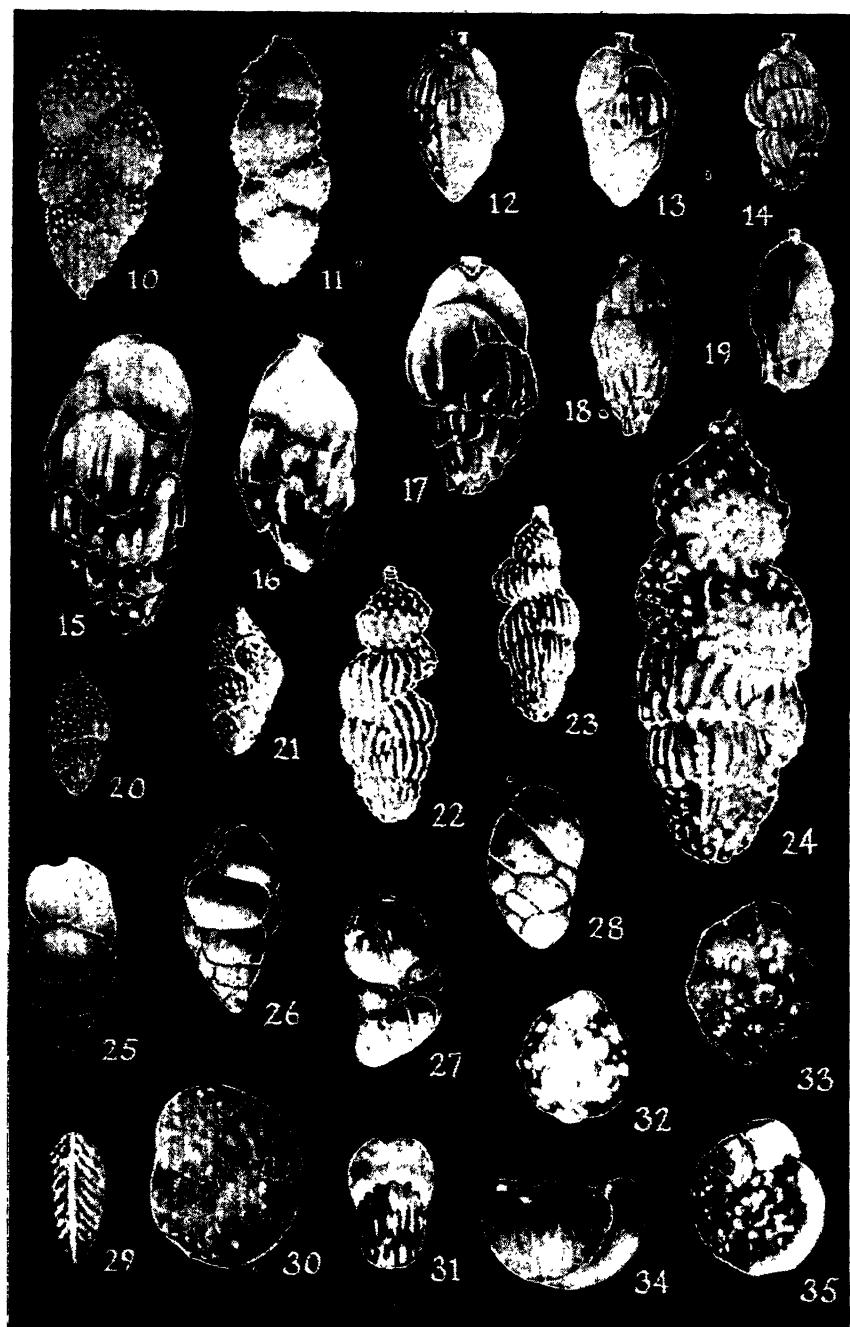


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FIG. 1.—*Cerobertina crepidula* n.sp.  $\times 90$ .  
 FIGS. 2, 3.—*Cerobertina bartrumi* n.sp. (2, holotype).  $\times 90$ .  
 FIGS. 4, 5.—*Cerobertina tenuis* (Chapman and Parr).  $\times 90$ .  
 FIG. 6.—*Uvigerina maynei* Chapman (topotype).  $\times 60$ .  
 FIG. 7.—*Plectofrondicularia pellucida*.  $\times 60$ .  
 FIG. 8.—*Siphogenerina reensis* n.sp.  $\times 60$ .







FIGS. 10, 11.—*Hopkinsina notohispida* n.sp. (10, microspheric holotype; 11, megalo-spheric).  $\times 30$ .

FIGS. 12-14.—*Uvigerina miozea* n.sp. (12, holotype).  $\times 30$ .

FIGS. 15-17.—*Uvigerina mioschwager* n.sp. (15, holotype; 16, from 5105, Clittrini's Area).  $\times 30$ .

FIGS. 18, 19.—*Uvigerina maynei* Chapman (Whaingaroa examples).  $\times 30$ .

FIGS. 20, 21.—*Hopkinsina cansea* n.sp. (21, holotype).  $\times 30$ .

FIGS. 22-24.—*Hopkinsina bortotara* n.sp. (23, holotype). 24  $\times 70$ ; others  $\times 40$ .



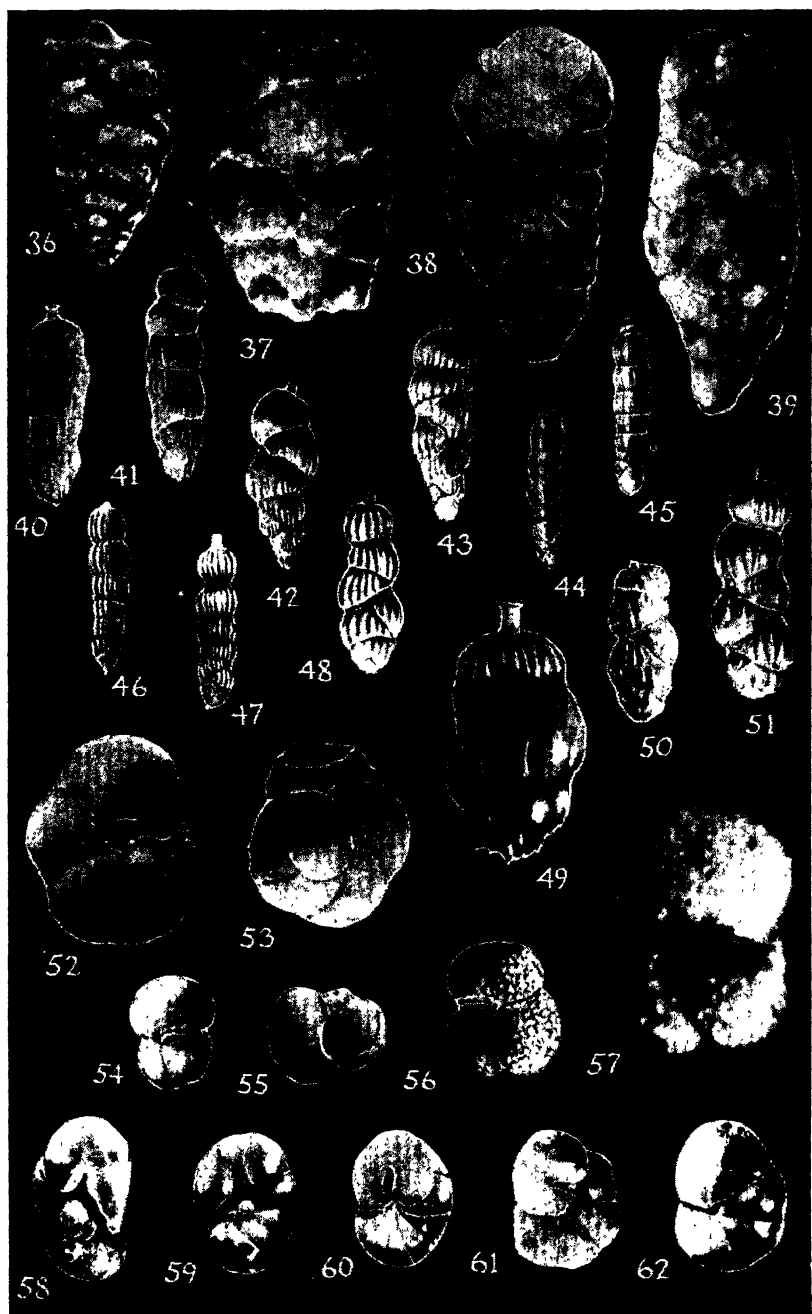


FIG. 36.—*Tritaxilina zelandica* n.sp.  $\times 15$ .  
 FIGS. 37-39.—*Tritaxilina languida* n.sp. (38, holotype; others from 5573).  $\times 30$ .  
 FIGS. 40, 41.—*Siphogenerina postprandia* n.sp. (41, holotype).  $\times 30$ .  
 FIGS. 42, 43.—*Siphogenerina ongleyi* n.sp. (43, holotype).  $\times 30$ .  
 FIGS. 44, 45.—*Siphogenerina pohana* n.sp. (45, holotype).  $\times 30$ .  
 FIGS. 46, 47.—*Siphogenerina vesca* n.sp. (47, holotype).  $\times 30$ .  
 FIGS. 48-51.—*Siphogenerina prisca* n.sp. (51, holotype). 49  $\times 90$ , others  $\times 45$ .  
 FIGS. 52, 53.—*Epomides lornensis* Finlay (52, holotype).  $\times 30$ .  
 FIGS. 54-57.—*Globigerina Unaperta* n.sp. (58, holotype). 57  $\times 60$ , others  $\times 45$ .





FIGS. 63, 64.—*Tertularia cuspsis* n.sp. (64, holotype).  $\times 30$ .  
 FIGS. 65, 66.—*Tertularia zeaggluta* n.sp. (65, holotype).  $\times 30$ .  
 FIG. 67.—*Tertularia marsdeni* n.sp.  $\times 15$ .  
 FIG. 68.—*Gaudryina fenestrata* n.sp.  $\times 30$ .  
 FIGS. 69-71.—*Gaudryina* (*Pseudogaudryina*) *proreussi* Finlay (69, holotype; 69, 70, microspheric; 71, megalospheric).  $\times 10$ .  
 FIGS. 72, 73.—*Verneulina brooni* n.sp. (72, holotype; 73, Hutchinsonian paratype).





## A New Freshwater Fish of the Genus *Philypnodon*.

By G. STOKELL.

[Read before the Canterbury Branch, July 6, 1938; received by the Editor, December 7, 1938; published separately, June, 1939.]

### TAXONOMY AND NOMENCLATURE.

THE Gobioid fishes of Australia, with which the New Zealand forms show close affinities, were revised in 1917–21 by McCulloch and Ogilby, who separate them into three sub-families, Periophthalminae in which the eyes are erectile and the base of the pectoral fin is very muscular, Gobiinae which has the ventral fins more or less united by a membrane, and Eleotrinae in which none of the above-mentioned features is present. In the subject of the present paper the eyes are not erectile, the base of the pectoral is not unduly muscular and the ventral fins are separate; it belongs, therefore, to the sub-family Eleotrinae or, as it is classed by some zoologists, the family Eleotridae. McCulloch and Ogilby recognise 13 Eleotrid genera, the more distinct of which are separated by the number of rays in the ventral fins, the presence or absence of bony crests on the head, the presence or absence of spines on the preoperculum and whether the number of scales in the longitudinal series exceeds or falls short of 50. The present fish has 6 rayed ventrals, it has neither bony crests on the head nor spines on the preoperculum, and the number of scales is less than 50; on these grounds it is disqualified for admission to 8 of the genera recognised. The remaining 5 are separated largely by the disposition of scales on the head, *Ophiocara* and *Mogurnda*, which are very closely related, having the head almost entirely covered with scales, *Carassiops* being scaled on the cheeks, opercles and occiput, but having the snout and interorbital space naked, while in *Gobiomorphus* the arrangement is very similar except that the cheeks are naked or carry only a few rudimentary scales. As the subject of the present paper has no scales on the cheeks, opercles, snout or interorbital space, and the remainder of the head is naked or sub-naked, it cannot be admitted to any of the foregoing genera. Of the remaining genus, *Philypnodon*, there is no further description in the paper referred to beyond the statement that the cheeks and opercles are naked, but reference to synonymous descriptions and comparison of the local fish with specimens of *Philypnodon grandiceps*, kindly forwarded by the Australian Museum and by the National Museum, reveals a close agreement in the characters mentioned and also in the arrangement of the body scales, which are smaller than those on the tail and deeply embedded. There is further agreement in the fin ray formula, the presence of papillae on the head and the absence of open pores, as well as in the vertebral count and in the circumstance of the caudal vertebrae being more numerous than those of the abdominal section. The principal differences between the two forms are that in *P. grandiceps* the head is longer, the gill-openings extend much further forward below, the maxillary is freer posteriorly, the genital papilla is smaller and the ventral surface is more completely scaled. These differences, although perhaps greater than those separating certain genera such as *Ophiocara*

and *Mogurnda*, do not seem sufficient to justify an addition to the existing list of Eleotrid genera, which, to the present writer, appears to have been unduly extended, and the local fish is here regarded as con-generic with the form known as *Philypnodon grandiceps*. The validity of the genus *Philypnodon* and the propriety of applying this name to any of these fishes are, however, open to question. This genus was founded by Bleeker (1874) to accommodate *Eleotris nudiceps* Castelnau (1872), which is described as being naked-headed and having teeth on the vomer, palatines and the tongue in addition to those on the jaws. As Bleeker's paper appears to be rather inaccessible, and the present writer is fortunate in possessing a copy, the definition of *Philypnodon* is reprinted below.

PHILYPNODON Blkr.

Dentes palatini et linguales. Dentes inframaxillares: intermaxillaribus longiores. Caput alepidotum. Nucha squamata. Squamae ctenoideae 47 circ. in serie longitudinali. D. 7-11. A. 11.

Spec. typ. *Eleotris nudiceps* Cast.

Waite (1903-05) has adopted this genus for the species *nudiceps* and *grandiceps*, which have no teeth on any part of the mouth except the jaws, on the grounds that Castelnau's description of the dentition of *E. nudiceps* was incorrect and that his species was the common Eleotrid of the Yarra River to which the name *Philypnodon nudiceps* is now applied. According to Ogilby (1897) no type or other specimen of *E. nudiceps* had been located, and the identification of this species with the common Eleotrid of the Yarra was based principally on the circumstances of locality and exclusive occurrence. Dr. Léon Bertin, of the Paris Museum National D'Histoire Naturelle, now informs the writer that three of Castelnau's types of *E. nudiceps* are in that institution and that they have no teeth on the vomer, palatines and tongues. Specifications of other structural characters kindly supplied by Dr. Bertin agree with those of the common Eleotrid of the Yarra known as *Philypnodon nudiceps*. The identification of this fish with Castelnau's species is therefore complete, and Castelnau's description as published is shown to be incorrect, but there seems no reason to suppose that the error was anything more than an accidental mistake in transcription.

The most complete description of these sub-naked headed Eleotrids is that of Ogilby (1897), who created for them the genus *Ophiorrhinus*, nominating as genotype *Eleotris grandiceps* Krefft (1864), a form so closely related to *nudiceps* that its specific distinctness seems open to question. Ogilby's genus, however, has no standing, as Bleeker had in 1874 created the genus *Gymnobotis* for *E. gymnocephalus* Steindachner (1866), a synonym of *E. grandiceps*. The definition of *Gymnobotis* is given below:—

GYMNOBOTIS Blkr.

Dentes maxillis pluriseriati subaequales, canini nulli. Caput prismaticum, aequè altum circ. ac latum, valde acutum, ubique alepidotum. Squamae 40 circ. in serie longitudinali. D. 7-10. A. 10.

Sp. typ. *Eleotris gymnocephalus* Steind.

This genus was defined in the same paper as *Philypnodon* but on a later page, the only claim to recognition that can be made on behalf of *Philypnodon* being based solely on this page precedence. The present writer submits that *Gymnobutis* has the better claim. The International Rules of Zoological Nomenclature include the following recommendation regarding the application of the law of priority:—"Other things being equal, that name is to be preferred which stands first in the publication (page precedence)."

In the present instance other things are by no means equal. They are equal in so far that both genera were based on published descriptions without reference to specimens, both have recognisable genotypes, and these genotypes, if not identical, are certainly congeneric, but there is no equality in the accuracy of the generic definitions. While the definition of *Gymnobutis* forms a reasonably accurate description of the fishes referable to this genus, *Philypnodon* is based expressly on characters that are non-existent in its component species. The anomalous position exists that if an Eleotrid possessing the dentition indicated in the definition of *Philypnodon* were discovered it could not be admitted to this genus; it would be excluded by the possession of those very characters upon which the genus is founded.

It is proposed to make the above circumstances the basis of an application for a ruling by the International Council, and, pending this decision, the name *Philypnodon* is tentatively retained.

The author wishes to express his thanks to Mr. G. P. Whitley, of the Australian Museum, and Mr. G. Mack, of the National Museum, Melbourne, for specimens of *P. grandiceps*, and to Dr. Léon Bertin, of the Paris Museum National D'Histoire Naturelle, for information regarding the types of *Eleotris nudiceps*.

***Philypnodon breviceps* n.sp.** (Plate 15, figs. 1-3.)

B. 6. D. vi-vii i 8-10. A. i 8-9. P. 14-15. V. 6. C. viii 15 ix. Vertebrae 29-31.

Caudal vertebrae the more numerous. Body somewhat depressed anteriorly, compressed posteriorly. Head 3.5-3.8 in length (without caudal fin), depth before ventrals 4.1-4.6 in same. Eye 3.9-5 in head, interorbital space 0.7-1.37 times the diameter of the eye. Depth of head 1.1-1.26 in width, snout rounded, mouth steeply inclined, the lower jaw usually slightly the longer, maxillary reaching to, or scarcely to, anterior of eye. Nostrils wide apart, the anterior tubular. Teeth multiserial, hooked, outer row definitely enlarged throughout in upper jaw, in lower jaw enlarged anteriorly. No teeth on vomer, palatines and tongue, pharyngeal bones with villiform and fine hooked teeth. Gill-opening not much extended below, usually narrower than the isthmus. Pseudobranchiae poorly and irregularly developed, gill-rakers obsolete. Rows of minute papillae on cheeks, opercles and around eyes, no open pores. Cheeks, opercles and interorbital space scaleless, top of head scaleless or with a few irregularly scattered imperfectly developed scales in the region of the nape of neck, sub-naked dorsal area usually extending to within a short distance of the origin of the first dorsal fin. A few scales extending

forward above the base of pectoral fin usually to about mid-way between cheek and rear of opercle. Base of pectoral scaleless, ventral surface usually scaleless to within a short distance of anus. Scales ctenoid laterally and dorso-posteriorly, becoming cycloid ventrally and dorso-anteriorly, fully imbricate on tail, but on the anterior part of the body steeply inclined in deep pockets with only a narrow edge protruding. The irregularity with which the scales are placed renders their enumeration a matter of uncertainty, but so far as may be determined there are from 43 to 48 counted longitudinally from above the base of the pectoral fin to the base of the caudal. The first dorsal fin is inserted at 0.36-0.38 of the length (without caudal) its form more or less rounded in some specimens, in others the top almost parallel with the base; aberrant forms with 5 developed rays and rudimentary ray articulated to either the first or last developed ray of fin. Height of second dorsal contained 1.3-1.55 in its length at base, rays about equal in length except the first two, which are shorter, last ray cleft to base. Origin of anal about perpendicular from fourth ray of second dorsal, its height contained 0.95-1.04 times in its length, last ray cleft to base. Caudal rounded, pectorals very broad and rounded. Caudal peduncle 1.52-2.05 times as long as its last depth. Genital papilla prominent, that in the female the larger.

Colour variable with the locality, in some specimens greyish with fins speckled darker, in others merging to yellow with reddish brown spots. A band of dull yellow across pectoral fins at base, top of first dorsal usually dark yellow or orange.

Maximum total length observed, 109 mm.

Types: Holotype and two paratypes in Canterbury Museum, two paratypes in Australian Museum, two paratypes in British Museum. Type locality Kowai River, tributary of the Waimakariri, Canterbury, New Zealand. Altitude 1800 feet.

Differs from *P. grandiceps* as already indicated and from *P. nudiceps* in most of the same characters, these two forms being very similar.

The present species is named *breviceps* on account of its comparatively short head.

#### *Variation.*

The variation in the number of vertebrae (29-31) is greater than has been observed in other New Zealand Eleotrids, and the extent of the scale covering is notably inconstant. In most specimens the ventral surface is naked to within a short distance of the anus, but in occasional ones it is covered with small cycloid scales from the rear of the ventral fins. The latter arrangement closely approximates that of *P. grandiceps*. There is also variation in the extent to which the dorsal surface is scaled anterior to the first dorsal fin; in examples of maximum scaling the complete dorsal covering commences about the perpendicular from the rear of the opercle. The depth to length ratio of the caudal peduncle varies, to some extent, with the size of



FIG. 1.—*Philypnodon breviceps*. Total length 96 mm.

—Photo by Miss T. R. Kent.



FIG. 2.—*Gobiomorphus* sp., showing dorsal surface fully scaled from posterior of eyes.

To face page 132.

FIG. 3.—*Philypnodon breviceps*, showing dorsal surface naked to within a short distance of first dorsal fin.



the fish, the larger specimens having the comparatively greater depth. Other characters such as fin ray formula show only normal variation. *Distribution and Habit.*

This fish has been collected from the Ashburton, Rakaia, Selwyn, Waimakariri, and Ashley Rivers and is probably widely distributed in the South Island. It occurs most plentifully in streams and lakes at altitudes exceeding 1000 feet where *Gobiomorphus gobioides*, for which it has hitherto been mistaken, is rare or absent. The latter fish, which has a more coastal habit, is readily distinguishable from *Philypnodon* by the difference in the scale covering on the head and nape shown in figs. 2 and 3. *P. breviceps* has not been taken in tidal water, but in rapid shingly rivers its range extends to within a short distance of tidal influence. Its food in alpine streams has been found to consist of larvae of Diptera, Plectoptera, Trichoptera, and Perlaria, and its spawning season appears to be about December. Specimens taken from the Harper River at the end of November were distended with ova measuring approximately 1.4 mm. in diameter, and apparently on the point of spawning.

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## New Zealand Seaweeds.—Reference List No. II.

### THE RHODOPHYCEAE—PART A

(Bangiales, Nemalionales, Cryptonemiales, and Gigartinales).

By ROBERT M. LAING, M.A., B.Sc., F.R.S.N.Z.

[*Read before the Canterbury Branch, October 5, 1938; received by the Editor, November 17, 1938; issued separately, June, 1939.*]

#### INTRODUCTION.

KYLIN has recently recast the Classification of the Rhodophyceae. Further, the nomenclature of many of our species has by him and other workers been altered. So it has become necessary to prepare a fresh list of species for the use of students of the subject. This is not, of course, a critical or definitive catalogue, but merely a check list to enable workers to follow what has been done up to date in the examination of any particular genus. This list should, therefore, be used in conjunction with previous catalogues or descriptions of species by Harvey, Agardh and others. There, further necessary information will be obtained. It is hoped, however, that here is provided a more accurate enumeration of our species than in any previous register of them, and that all forms that have been described with sufficient accuracy for re-identification are included. This list also includes a few species not yet published, but these will probably be in print before this appears.

Many difficulties are encountered in any attempt to draw up such a catalogue as this. Indeed, the more one investigates, the more unsure the foundations appear. In all the large and polymorphous genera many of the species have originally been described from insufficient material, and cannot be determined without reference to the type specimens, and often not then. Consequently the range of forms that should be included within the limits of a given species is frequently unknown. Further, there are many cases of the same species, when from different localities, being described under different names, and still more instances where the same name has been applied to different species. This is largely due to the tendency of the earlier workers to assimilate our species with British, Australian or other widely spread forms, and has caused much confusion in our nomenclature—a confusion which is still far from being eradicated. Further research tends always to increase the amount of endemism displayed by New Zealand forms.

Too little is known about the internal distribution to enable one to give the range of each species within New Zealand; but all species are included in this list which are known from any station between the Kermadecs and Campbell Island, and also from the Chathams. It is obvious that in such a wide range of latitude, differences of illumination, sea temperatures, and of environment generally must be sufficiently great to set bounds to the distribution of many species. Further, our knowledge is limited by the small number

of places at which intensive collections have been made. Very little collecting has been done on the West Coast of New Zealand by any investigators. True, both in the North and South Islands, long stretches of this coast are barren of seaweed; but there must be on the West Coasts of both islands many points where rich harvests of marine algae are yet to be obtained. What little collecting has been done on the West Coast has, however, so far tended to show that the species obtainable there are not markedly distinct from those on the East. As might be expected, what does definitely appear is that many species are confined to the Northern region of New Zealand and many others to the Southern. An attempt is here made to distinguish some of these, the Northern species being marked (N) and the Southern (S); but no endeavour has been made to draw a definite geographical line of separation between them. Though some of the Northern species may be confined to the Kermadecs only, others may range as far South as Wellington; and on the other hand, though some of the Southern species are definitely sub-antarctic, others may come as far North as Cook Strait. So far very few species have been delimited which appear to have a definitely Central distribution, but no doubt there are a few. Many forms range throughout the length of both islands, others are known from only one or two localities; but our ignorance of distribution is such that in most cases we are quite unable to give the exact range of any particular species.

This list deals, therefore, chiefly with the species of the East Coast of New Zealand. Probably the region that has been most closely examined is the Bay of Islands. Most collectors have reaped a rich harvest there, and it is again being very thoroughly searched round the year by Mr V. W. Lindauer. In most other districts collections have been more or less seasonal or irregular. However, the neighbourhoods of Auckland, Wellington, Lyttelton and Dunedin have all been fairly well investigated, and collections have also been made at Hawke's Bay, Kaikoura, Akaroa, Timaru, The Bluff, Stewart Island and other places. The last-named place, if properly examined, would yield a rich harvest of new species, and one may hope much from its recent investigation by Professor Tilden and her students.

The list of habitats or range given to each species here can, therefore, in most cases only be regarded as provisional. Fuller details of its occurrence will be found in the writings of earlier phycologists. The general external distribution of each so far as is known has also been briefly given; but only such synonymy is given as will connect the species with other lists.

My thanks are due to many workers for assistance in the preparation of this list. In New Zealand special mention should be made of the help given by Mr V. W. Lindauer, of the Bay of Islands, who, besides typing this list, has given most willing aid in many ways. Miss L. M. Cranwell, of Auckland Museum, has also contributed the names of some species; and, abroad, Professor Setchell,

Dr Kylin, and Dr Feldmann have lent their assistance in the determination of various specimens. The absence of type-forms in New Zealand is a great drawback to workers here, but the list of our species is slowly assuming a more reliable form.

# RHODOPHYCEAE.

## Subclass PROTOFLORIDEAE.

### Order BANGIALES.

#### Family BANGIACEAE.

#### BANGIA Lyngbye.

In all seas.

**Bangia fusco-pupurea** (Dillw.) Lyngb. (1819), *Hydrophyt. Dan.*, p. 83.

Dunedin, New Brighton, Homewood (Pelorus), R. M. L.

Possibly common. Widely distributed.

**Bangia lanuginosa** Hook. et Harv. (1855), 2, p. 264. "Parasitic on *Chordaria* Colenso."

Endemic. A very questionable species which has not been recently identified.

# ERYTHROTRICHIA.

Very widely distributed.

\***Erythrotrichia hunterae** Gardner (1936), p. 341.

This replaces *E. ciliaris* (?), v. Lg. (1928), p. 55. It is evidently a distinct and probably endemic species.

On *Zostera*, Cook's Straits, Lyall; on *Zostera nova-zelandica* Setch., Church Bay, Lyttelton, H. Hunter; Akaroa, R. M. L. Probably to be found wherever *Zostera* is abundant. Endemic.

# PORPHYRA J. Ag.

In all seas.

**Porphyra columbina** Mont. (1842), Prodr. Antarc., p. 14. (= *P. nobilis* J. Ag.)

Auckland Island, D'Urville.

Common on the coasts between half tide and high water mark, R. M. L.

For a discussion of the characters of this species v. Lg. (1928), p. 39. Endemic.

**Porphyra subtumens** J. Ag. (*nom. nud.*) Lg. (1928), p. 45.

Always epiphytic on *D'Urvillea*, and perhaps common wherever *D'Urvillea* is found in New Zealand. Endemic.

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\* Species marked thus have not been included in preceding lists.

**Porphyra umbilicalis** (L.) J. Ag. var. *novae zelandiae* Lg. (1928), p. 53.

In one form or another almost cosmopolitan.

# ERYTHROCLADIA ROSENV.

In most seas.

**Erythrocladia** (??) *insignis* Lg. (1928), p. 56.

Endophytic in *Porphyra*, and probably occurring wherever *P. columbina* and *P. laciniata* var. *novae-zelandiae* are found.

The genus is quite doubtful. Endemic.

\***Erythrocladia sub-integra** Rosenvinge (1909, *The Marine Algae of Denmark*, p. 73.

In terminal segments of *Chaetomorpha darwini*, Timaru, North Mole.

Identified by Dr J. Feldmann.

North Atlantic and Indian Oceans in species of *Chaetomorpha*.

# Order NEMALIONALES.

The New Zealand species of this order remain mostly unexamined or unidentified. The few that have been identified are often imperfectly known, and their present identifications cannot always be regarded as completely reliable.

# Family CHANTRANSIACEAE.

## ACROCHAETIUM Naeg.

In all seas.

**Acrochaetium corymbiferum** (Thur.) Batters. (1902), p. 5 (= *Chantransia corymbifera* Thur.)

The Bluff, Capra, on *Stilophora rhizoides* (De Toni et Forti, 1923, p. 14). Widely distributed.

\***Acrochaetium interpositum** (Heydr.) Hamel (1928), p. 187.

In the fronds of *Codium mucronatum* f. *novae-zelandiae*, Bay of Islands, Heydrich.

This replaces *Chantransia naumauni* Asken. of the previous list, which is a Cape Verde species, and quite distinct. Endemic.

**Acrochaetium (Chantransia) polyrhizum** (Harv.) J. Ag. (1892), *Anal. Algol.*, p. 48.

Port Chalmers, Capra. Australia.

# Family BATRACHOSPERMACEAE.

## BATRACHOSPERMUM Roth.

Widely distributed, chiefly in fresh water.

The New Zealand species have recently been collected by Miss

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\* Species marked thus have not been included in preceding lists.

E. A. Flint and Miss L. M. Cranwell, and have been named by Skuja; but so far as I know descriptions have not yet been published.

\***Batrachospermum atrichum** Skuja, sp. ined.

Stream in Anita Bay, Milford Sound, E. A. Flint. Endemic.

\***Batrachospermum campyloclonum** Skuja, sp. ined.

Running streams, Canterbury plains; Lyall; Inchbonnie (Westland), E. A. Flint; near Whangarei, L. M. C.

This replaces in part *B. moniliforme* Roth. of previous lists. Endemic.

\***Batrachospermum dillenii** Bory (1808), *Ann. Mus.*, 12, p. 310.

Anawhata, Auckland, L. M. C.

\***Batrachospermum fruticans** Skuja, sp. ined.

Cleddau River, Milford Sound; Inchbonnie, West Coast; E. A. Flint.

\***Batrachospermum gallaei** Sirodot var. *longifolium* Skuja, var. ined.

Avon, Christchurch, R. M. L; Anawhata, Te Henga, L. M. C.

\***Batrachospermum novae zelandiae** Skuja, sp. ined. (Sub. *B. moniliforme* partim Roth. Harvey, *Fl. Nov. Zel.*, 2, p. 261).

Fresh water streams on the Canterbury Plains, Lyall, Whangarei, Waipoua Forest, Henderson, L. M. C. Endemic.

#### SIRODOTIA Kylin.

Widely distributed.

\***Sirodotia fennica** Skuja, sp. ined.

Cass, small stream draining a swamp, E. A. Flint. Endemic.

\***Sirodotia suecica** (Aresch.) Kylin (1912), *Stud. ueber Arten der Gattung Batrachospermum und Sirodotia*, p. 38.

The material is poor, and the determination by Skuja not quite certain. Hitherto confused with *Batrachospermum vagum* Bory var. *dillenii* Aresch.

Sweden.

#### Family HELMINTHOCLADIACEAE.

NEMALION Targioni Tozzetti.

Probably widely distributed, but not well known.

**Nemalion ramulosum** Hook. et Harv. (1855), *Fl. Nov. Zel.*, 2, p. 245.

Otea, Lyall.

A very questionable species. Endemic, and not sufficiently known, but v. Harvey Gibson (1893), p. 5.

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\* Species marked thus have not been included in preceding lists.

**LIAGORA** Lamour.

In all warmer seas.

**Liagora harveyana** Zeh Ms.; in A. D. Cotton (1912), p. 258.

Little Barrier, Tiri-Tiri, E. M. Smith (N), Indian Ocean.

I have specimens of what appear to be three New Zealand species of *Liagora* from (a) Little Barrier, (b) Motu Arohia, Bay of Islands, (c) Crusee Islands, Motuihi, etc. The Little Barrier specimen is certainly very close to *L. viscida* (Forsk.) Ag.; but the matter will have to be left thus till more material is obtained and better identifications made.

**HELMINTHORA** J. Ag.

In European and Australian seas.

\***Helminthora divaricata** (Ag.) J. Ag. (1851), sp. vol. 2, p. 416.

East Coast of Otago, Kuri Bush to Moeraki, R. M. L.

*H. divaricata* is widely distributed in Atlantic, Mediterranean, and Australasian seas. The New Zealand form shows small differences from the type which may or may not be specific. One or more species of *Helminthocladia*, and probably *Cumagloia*, still unidentified also occur on the New Zealand coasts.

Family **CHAETANGIACEAE**.

**SCINAIA** Bivona.

Widely distributed in most warmer seas.

**Scinaia furcellata** (Turner) Bivona (1822) var. *australis* J. Ag. (1876), p. 712.

A somewhat questionable New Zealand species. The plant so identified is, perhaps, the following species, but a comparison with the type is necessary. Specimens from the Bay of Islands collected by V. W. L. are in the hands of Prof. W. A. Setchell and will be identified by him. Widely distributed.

**GLOIOPHLAEA** J. Ag.

Australasian seas.

**Gloiophlaea scinaoides** J. Ag. (1870), p. 29; (1876), p. 510.

Lyttelton, Wellington, R. M. L.; Bay of Islands, Berggren, V. W. L.; Auckland, L. M. C.

I doubt if our species is the same as the Australian. Victoria.

**PSEUDOSCINAIA** Setch.

Lower California and Australasian seas.

\***Pseudoscinaia australis** Setch. (1914), p. 128.

Not common, from the Bluff to the Bay of Islands.

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\* Species marked thus have not been included in preceding lists.

## GALAXAURA Lam.

In most warmer seas.

**Galaxaura** sp.

One or more species of *Galaxaura*, as yet unidentified, occur at the Kermadecs (N.), Meyer Island, A. et E. S. Gepp. A species collected also by H.M.S. Herald in 1854 was placed under *G. lapidescens* in Kew Herbarium. Greunow, *Novara*, p. 76, records *G. driesingiana* Zanard. This record requires further confirmation.

## CHAETANGIUM Kuetz.

South temperate and sub-antarctic seas.

**Chaetangium variolosum** (Mont.) J. Ag. (1851), p. 461.

This may be only a form of *C. fastigiatum* J. Ag. (v. Cotton, *Cryptog. from the Falklands*, p. 175).

New Zealand, Aucklands, Campbell Is. Not very common, but occurring at intervals along the coast to as far north as (Bethell's) McGaffrey's Bay on the west coast, near Auckland. It appears to be more luxuriant in the South, and my finest specimens are from Campbell Island. Different species may be confused in this.

Western Australia, and widely distributed in the sub-antarctic.

## Family GELIDIACEAE.

## CAULACANTHUS Kuetz.

In most warmer seas.

**Caulacanthus spinellus** (Hook. f. et Harv.) Kuetz (1849), p. 753.

Common along the coasts as far North as the Bay of Islands, also at the Chathams.

According to Okamura (1932), *Distribution of Marine Algae in Pacific Waters*, an article to be used with discretion, it is also found in most warmer southern seas.

**Caulacanthus ustulatus** (Mert.) J. Ag. (1876), p. 580.

In New Zealand only known so far from the Bay of Islands, R. M. L., V. W. L.

Widely distributed in temperate and sub-tropical seas. Probably there are several forms of *Caulacanthus* in New Zealand, not yet sufficiently discriminated.

## GELIDIUM Lmx.

In most warmer seas.

**Gelidium asperum** (Mert.) Grev.

*G. asperum* is an Australian plant, recorded from New Zealand by J. Ag. (1851), p. 475, but subsequently dropped. No doubt most of the forms from N.Z. placed under *G. corneum* by earlier collectors belong either to this species or to *Pterocladia capillacea* (v. under).

Bay of Islands, V. W. L.

**Gelidium caulacanthum** J. Ag. (1876), p. 548.

Lyttelton to Bay of Islands, common, but apparently not known at present south of Lyttelton.

**Gelidium corneum** (Huds.) Lmx. (1813), *Ess.*, p. 41.

I am leaving this species on our list with considerable misgiving. The actual type form is still "a bone of contention" with northern algologists. Much of the material recorded as this by earlier investigators was undoubtedly *Pterocladia capillacea* (= *G. corneum* var. *capillaceum*). As, however, the species has been recorded both by Harvey and Agardh, I am retaining it for the present. Undoubtedly we have forms of *Gelidium* somewhat similar to *G. corneum* in one or more of its many varieties, but these can only be determined by actual comparison with the types.

A form collected at the Bay of Islands by V. W. L. certainly comes close to typical *G. corneum*.

An almost cosmopolitan species in one form or another.

\***Gelidium crinale** (Turner) Lmx. (1825), p. 191.

Long Beach (Bay of Islands), V. W. L. Identified by W. A. S.

Widely distributed in Mediterranean, Atlantic and Japanese Seas.

**Gelidium longipes** J. Ag. (1876), p. 547.

Bay of Islands, Berggren, V. W. L.; Kermadecs, W. R. B. O. Endemic.

**Gelidium microphyllum** (= *Nitophyllum* ? *microphyllum* Smith, Lg., 1902) Kylin (1934), p. 2.

This distinct little species has only been collected once. It was found on the back of a *Halotis* shell near Dunedin.

\***Gelidium subuliferum** Harv. (= *G. corneum* var. *subuliferum*).

I have several specimens from Keri Keri, thus identified by Reinbold, and introduce the name here for the sake of completeness. The whole genus requires re-investigation for New Zealand. Other undetermined species exist here, one very close to the Australian *G. australe*. Bornet refers to the genus as "genre diabolique." Let us hope N.Z. algologists will not find it so.

**PTEROCLADIA** J. Ag.

Widely distributed.

**Pterocladia capillacea** (Gmel.) Born. et Thur. (1876), *Not. Alg.*, p. 57.

From Wellington northwards, apparently becoming more abundant towards the north (N.). It occurs in various forms which, so far, have not been studied.

Widely distributed.

\* Species marked thus have not been included in preceding lists.

**Pterocladia lucida** (R. Br.) J. Ag. (1851), p. 483.

Apparently common in at least two forms from Kaikoura northward. It has also been found at the Chathams and at various islands off the East Coast of Auckland.

The type species of the genus.

Australia.

#### Family WRANGELIACEAE.

**WRANGELIA** C. Ag.

N. Atlantic and Australian seas.

**Wrangelia lyallii** Hook. f. et Harv. (1855), 2, p. 245.

From the Bluff northwards to Lyttelton (S.).

Endemic.

#### Family BONNEMASIONIACEAE.

**PTILONIA** J. Ag.

Australasian and Fuegian seas.

**Ptilonia magellanica** (Mont.) J. Ag. (1852), p. 774.

“East Coast, Lyall.”

The occurrence of this sub-antarctic species in New Zealand requires confirmation.

**DELISEA** Lmx.

Australasian, Indian and sub-antarctic seas.

**Delisea elegans** (C. Ag.) Hook f. et Harv. (1844), *Lond. Journ. Bot.*, p. 442.

Stewart Island to Wellington, sub-littoral, usually obtained only in dredging or drift.

S. and E. Australia, Tasmania, Indian Ocean.

**Delisea pulchra** (Grev.) Mont., *Ann. Sc. Nat.*, ser. 3, vol. 7, p. 158.

Only so far known in New Zealand from Kermadecs and North Auckland, but probably occurs further south as well.

Australia, Tasmania, South Georgia, Graham Land, Indian Ocean, Japan.

**ASPARAGOPSIS** Mont.

Widely distributed in warmer seas.

**Asparagopsis armata** Harv. (1855), p. 544.

Apparently usually sub-littoral, but occasionally found on the coasts throughout the Islands.

Pacific coast of America, Tasmania, Australia, and Mediterranean.

**Asparagopsis sandfordiana** Harv. (1855), p. 544.

Kermadecs, W. R. B. O. (N.).

This is questionably distinct from *A. taxiformis*, Delile, v. Lucas (1935), *Marine Algae of Lord Howe Island*, *Proc. Linn. Soc. of N.S.W.*, vol. 60, p. 232.

Order CRYPTONEMIALES.

Family SQUAMARIACEAE.

**PEYSSONNELIA** Decaisne.

In most warmer seas.

**Peyssonnelia rubra** (Grev.) J. Ag. (1851), p. 502.

Kermadecs, W. R. B. O. (N.).

An endemic sp., *P. rugosa*, is recorded from Cape Kidnappers, Harv., (1855), 2, p. 245, but as it was sterile, it remains very doubtful.

**HILDENBRANDIA** Nardo.

\***Hildenbrandia le canellieri** Hariot (1886), *Mission Scientifique du Cap Horn*, Algues, p. 81.

Auckland, L. M. C.

Magellan Straits.

\***Hildenbrandia crouanii** J. Ag. (1851), p. 495.

Anawhata, and fairly widely distributed, L. M. C.

In European seas.

\***Hildenbrandia rivularis** Liebm. (1839), *Kröy. Tidskr.*, p. 174.

Waitakerei Ranges, Taranga Is., L. M. C.

European.

Family CORALLINACEAE.

No New Zealand specimens, so far as I know, have been examined since my previous list (*Trans. N.Z. Inst.*, 1926, p. 129). It is hoped, however, that a fresh examination will shortly be made. It does not seem necessary, therefore, to relist them here, and older lists should be consulted, if required, together with the excellent re-investigation of the family by Suneson (1937), *Lunds Univ. Arsskrift*, bd. 33, no. 2.

Family GRATELOUPIACEAE.

**GRATELOUPIA.**

In most warmer seas.

**Grateloupia flicina** (Wulf.) J. Ag. (1851), p. 180.

Chathams, Rbd.

In most temperate and sub-tropical seas.

The species of *Grateloupia* are highly polymorphic, and until the limits of each form are known, it is obvious that they cannot be strictly defined. I have only one specimen, from Kaingaroa, Chatham

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\* Species marked thus have not been included in preceding lists.

Islands, that can be placed here; and of it I am somewhat doubtful. One or two undescribed species of *Grateloupia* also appear in my collection. The whole genus really requires re-identification for New Zealand and comparison with sets of specimens from elsewhere.

***Grateloupia polymorpha*** (Hook. f. et Harv.) Lg., *nom. nov.* (= *G. pinnata* (H. et H.) J. Ag.)

As the specific name *pinnata* is preoccupied in *G. pinnata* (P. et R.) Setchell, I have replaced it for our species. The plant was originally put in the genus *Nemastoma* by Harvey, and divided into three species (*N. pinnata*, *N. davisii* and *N. endiviaefolia*). J. Agardh, in removing it to the genus *Grateloupia*, replaced the species by varieties. Until full collections of the plant from different places and at different stages of growth are made, these varieties should, I think, be left to stand.

The species occurs abundantly on tidal rocks and in pools from Otago to the Bay of Islands.

Perhaps endemic, though *G. australis* from Australia in some of its forms closely approaches it.

***Grateloupia prolifera*** J. Ag. (1876), p. 150.

On tidal rocks and boulders, from the Bluff to the Bay of Islands, common. New Zealand, the Chathams.

Tasmania.

***Grateloupia stipitata*** J. Ag. (1876), p. 151.

Dunedin, Berggren.

I have a specimen thus identified by Agardh, but it is obviously only a form of a highly polymorphic species abundant along the coasts of both Islands. It includes forms which might be identified as *G. filicina*, but apparently far outranges that species in the multitude of its varieties.

Possibly endemic.

#### AEODES.

N. American Pacific and N.Z.

***Aeodes nitidissima*** J. Ag. (1876), p. 680.

Tauranga to Mangonui. Crusoe Island, L. M. C. (N.).

Perhaps endemic, as the American species, *A. gardneri*, according to Kylin, is distinct.

#### CRYPTONEMIA J. Ag.

In many warm seas.

***Cryptonemia latissima*** J. Ag. (1876), p. 682.

Bay of Islands, Berggren.

Endemic.

**HALYMENIA** (C. Ag.) J. Ag.

Most warmer seas.

\***Halymenia lindaueri** Setch., sp. ined.

Bay of Islands, V. W. L.

Endemic.

**PACHYMENIA** J. Ag.

Japanese and Southern temperate seas.

**Pachymenia dichotoma** J. Ag. (1876), p. 146.

Bluff, Berggren.

The various forms of this polymorphic genus are as yet insufficiently known, and consequently the distribution of the species within New Zealand is unknown. I doubt if all the species described by Agardh are really distinct. I have no definite forms of this from north of Otago (S.).

Endemic.

**Pachymenia himantophora** J. Ag. (1876), p. 680.

Bay of Island, Berggren.

West Coast near Auckland, Whangarei Heads, L. M. C.

Apparently to be found on most open rocky coasts, but, perhaps, commoner in the Auckland Province.

Endemic.

**Pachymenia laciniata** J. Ag. (1876), p. 145.

Bluff, Dunedin, Berggren.

Apparently common on open coasts, but requires further investigation.

Endemic.

**Pachymenia lusoria** (Grev.) J. Ag. (1876), p. 146.

This is the original N.Z. species; but its limits have never been satisfactorily described or examined.

The Antipodes, Snares, Otago, Banks Pen., and, perhaps, extending far to the North, but certainly far more abundant in the South (S.).

Endemic.

**THAMNOCLONIUM** Kuetz.

Malay Archipelago and Australasian seas.

**Thamnoclonium claviferum** J. Ag. (1876), p. 168.

Foveaux Str. (ident. Rbd.), R. M. L.

Australia, Tasmania.

## Family CALLYMENIACEAE.

## CALLOPHYLLIS Kuetz.

Widely distributed.

**Callophyllis calliblepharoides** J. Ag. (1876), p. 231.

From Foveaux Straits to Wellington, The Chathams, and Auckland Islands (S.).

Questionably distinct from *C. hombroniana*.

Endemic.

**Callophyllis centrifuga** J. Ag. (1876), p. 688.

Only known from Bay of Islands, Berggren.

Endemic.

**Callophyllis coccinea** Harv. (1847), *Alg. Tasm.*, p. 8.

var. *carnea* J. Ag. (1876), p. 234.

var. *crinalis* J. Ag. (1876), p. 234.

A very polymorphic species.

The only definite locality known on the mainland seems to be Tauranga, but it has not been recently collected there. The Chathams. I have a specimen from Stewart Island that might well be placed here.

Southern Australia, Tasmania (the type locality).

**Callophyllis decumbens** J. Ag. (1876), p. 688.

Fishermen's net, Lyall Bay, R. M. L.; Bay of Islands, Berggren.

Endemic.

**Callophyllis hombroniana** (Mont.) Kuetz. (1849), p. 746.

Common on rocky coasts of the South Island, Aucklands and Chathams (S.).

Endemic. (The locality Amsterdam Island—*Botany of the Novara*—is probably erroneous.)

**Callophyllis lambertii** (Turn.) Hook. f. et Harv. (1847), *Alg. Tasm.*, No. 55.

A very doubtful indigene. I have seen no New Zealand specimens. It was originally identified for N.Z. by Reinhold from specimens collected at New Brighton by Dr. Schauinsland. These might well have been some form of the polymorphic *C. coccinea*, but a whole series of specimens is required.

**Callophyllis ornata** (Mont.) Kuetz. (1849), p. 746; v. also Kylin (1931), p. 11.

Auckland Islands. Campbell Is., R. M. L. (S.).

**Callophyllis tenera** J. Ag. (1849), *Act. Holm.*, p. 87; (1876), p. 235.

Dunedin and Banks Pen., Berggren; Moeraki, Lyall's Bay, R. M. L. (S.).

New Zealand, Chathams.

It may be doubted whether this is the same as the Fuegian *C. tenera*; what has in part, at least, been re-identified as *Craspedocarpus erosus*.

South Shetlands, Fuegia, Falklands, Kerguelen.

***Callophyllis variegata*** (Bory) Kuetz. (1843), *Phyc. Gen.*, p. 400, t. 69.

Tauranga, Davies; Paterson's Inlet, R. M. L.

New Zealand, Aucklands.

There are a large number of varieties, and it may be doubted whether all belong to the same species. The type is from New Guinea, v. Howe (1914), p. 119.

New Guinea, Peru, Chili, Fuegia, Falklands, Kerguelen, South Orkneys, Graham's Land.

#### ECTOPHORA J. Ag.

An endemic genus.

I previously followed Schmitz in uniting this genus with *Callophyllis* (v. Lg., 1926, p. 152), but think now it should be kept separate.

***Ectophora depressa*** J. Ag. (1876), p. 690.

Bay of Islands, Berggren, V. W. L.

Endemic.

***Ectophora dichotoma*** J. Ag. (1876), p. 691.

This should not be confused with *Callophyllis dichotoma* Kuetz. (1849), p. 746, which is a different plant from Campbell Is. The present species was described by J. Ag. from one specimen and some fragments (*l.c.*) which were sterile, and as it does not appear to have been collected since, it is an altogether doubtful species.

Bay of Islands, Berggren.

#### DACTYLYMENIA J. Ag.

An endemic genus.

***Dactylomenia berggreni*** J. Ag. (1899), p. 54; *Kallymenia berggreni* (J. Ag.), 1876, p. 221.

A doubtfully distinct species, requiring further investigation. Perhaps the same as *Kallymenia harveyana*, *Fl. N.Z.*, 2, p. 251.

Bluff, Lyall's Bay, Bay of Islands, Berggren. Apparently not uncommon on the coasts.

Endemic.

***Dactylomenia digitata*** J. Ag. (1899), p. 52.

J. Ag. gives no locality further than New Zealand for this species. I have one or two specimens from Wellington Harbour that I have placed here, but they are possibly insufficiently separated from the following species.

***Dactylomenia laingii*** J. Ag. (1899), p. 54.

Akatore, Black Head, Dunedin, Karaka Bay, Muritai, R. M. L.

Endemic.

## RHIZOPOGONIA Kylin.

An endemic genus.

**Rhizopogonia asperata** (Hook. f. et Harv.) Kylin (1934), p. 6.  
 (= *Chrysymenia asperata* (H. et H.) Cotton (1809), p. 241; = *Chrysymenia* (?) *apiculifera* J. Ag. (1876), p. 320.)

Akaroa, Lyttelton, R. M. L.; Lyall's Bay, Berggren; Port Nicholson, Lyall, the type locality.

## Order GIGARTINALES.

## Family NEMASTOMACEAE.

## NEMASTOMA J. Ag.

Widely distributed.

**Nemastoma intestinalis** Hook. f. et Harv. (1855) 2, p. 255.

Preservation Harbour, Lyall.

New Zealand, the Chathams.

The species of this genus are badly in need of re-determination.

This has probably been confused with *Grateloupia prolifera*.

Endemic.

**Nemastoma laciniata** J. Ag. (1876), p. 128; v. also Kylin (1932), p. 7, where he shows that J. Ag. re-described this species as *Schizymenia stipitata*.

Banks Peninsula, Berggren.

Common along the coast on exposed rocks near low tide, and occasionally in tidal pools. In some of its forms very close in appearance to the European *Schizymenia dubyi*.

Japan.

\***Nemastoma laingii** Kylin (1932), p. 8.

In the absence of cystocarpic specimens the genus is somewhat uncertain.

Brighton, Otago, R. M. L.

Endemic.

**Nemastoma oligarthra** (J. Ag.) Kylin (1934), p. 1. (= *Catenella oligarthra* J. Ag.)

Coromandel Pen. to Bay of Islands (N.).

The genus is somewhat doubtful. Endemic.

## SCHIZYMENIA J. Ag.

Widely distributed.

**Schizymenia novae zelandiae** J. Ag. (1876), p. 677.

Bay of Islands, Berggren.

Not uncommon from Otago northwards.

Endemic.

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\* Species marked thus have not been included in preceding lists.

Family SEBDENIACEAE.

SEBDENIA Berth.

A genus widely distributed in the warmer seas of the Pacific and Indian Oceans.

**Sebdenia** (?) sp.

Toni et Forti (1923), p. 31, have identified a seaweed collected at Port Chalmers as *S. (?) callymenioides*. What it really is I don't know; but it is certainly not *Halymenia callymenioides* Harv., *Trans. Irish Acad.*, vol. 22, p. 56, as suggested. The plant originally described by Harvey under this name was later confused by him with another species, and redescribed and figured as *H. cliftoni*. *H. cliftoni* is now *Leptosomia cliftoni* (Harv.) J. Ag., v. Kylin (1931), p. 19; but the original plant of Harvey was probably a true *Halymenia* (v. Kylin, *loc. cit.*).

The Port Chalmers plant, whatever it may be, is, therefore, not entitled to the specific name *callymenioides*, as it is evidently not a *Halymenia*.

Family GRACILARIACEAE.

CURDIAEA Harv.

In Australasian Seas.

**Curdiaea coriacea** (Harv. f. et Harv.) J. Ag. (1876), p. 401.

Comparatively common along the East Coast from Stewart Island as far north as Lyall's Bay, usually in the *D'Urvillea* belt.

Endemic.

**Curdiaea crateriformis** (J. Ag.) Kylin (1932), p. 61. (= *Sarcocladia (?) crateriformis* J. Ag. (1876), p. 697.)

Hokianga and Bay of Islands, Berggren; O'Neil's Point,, L. M. C.; Bay of Islands, V. W. L. (N.).

Probably endemic.

**Curdiaea engelhartii** J. Ag. (1901), p. 105.

East coast of both islands, as far north as the Bay of Islands; not common.

Akatore is the type locality.

Australia.

**Curdiaea laciniata** Harv. (1856), *Ann. Nat. Hist.*, ser. 2, vol. 15, p. 333.

Bay of Islands, Cook Strait, Lyall; Otago, Lindsay.

I have seen no N.Z. specimens, and doubt the occurrence of this in N.Z. Quite possibly one of the other species of the genus may have been confused with it. Apparently it was not collected by Berggren.

Australia, Tasmania.

## GRACILARIA Grev.

Almost cosmopolitan.

(The New Zealand species of this genus require redetermination.)

**Gracilaria confervoides** (L.) Grev. (1830), *Alg. Brit.*, p. 123.

Common along the east coast, the Kermadecs.

Almost cosmopolitan.

**\*Gracilaria disticha** J. Ag. (1837), *Alg. Rüpp.*, p. 172; *Epicr.* (1876), p. 416; (1901), p. 79.

I insert this for the sake of completeness. I collected some specimens at Moeraki which Agardh thus identified; but I am not at all well satisfied that they do not belong to the somewhat polymorphous *G. flagellifera* (q.v.) or to *G. secundata* J. Ag.

Red Sea, Indian Ocean.

**Gracilaria dura** (C. Ag.) J. Ag. (1852), p. 589; J. Ag. (1901), p. 61.

Bluff, Berggren; Kuri Bush, R. M. L.

Doubtfully the same as the European species, but without sets of specimens from different areas the identity or otherwise can scarcely be determined. Agardh had only one specimen from New Zealand.

Europe, Mediterranean, India, West Indies, American Atlantic coast, etc.

**Gracilaria flagellifera** J. Ag. (1876), p. 412.

Chatham, Mueller.

This appears first as a *nomen nudum*, *T.N.Z.I.*, vol. 6, p. 209.

Apparently a common species on the east coast of Otago (S.); but v. J. Ag. (1901), p. 67.

Endemic.

**\*Gracilaria harveyana** (?) J. Ag. (1885), p. 59; J. Ag. (1901), p. 65.

Chatham, Dr. Schauinsland.

Some specimens collected by me at Gore Bay are doubtfully placed here by Prof. W. A. Setchell.

S. and W. Australia.

**Gracilaria lichenoides** (L.) Harv. (1844), p. 445; J. Ag. (1901), p. 52.

This is reported from New Zealand by Agardh (*loc. cit.*), but no collector's name or locality is given.

New Guinea, Australia, Tasmania, Indo-China.

**\*Gracilaria paradoxa** (?) (Harv.) J. Ag. (1901), p. 67.

Doubtfully thus identified for me by W. A. S., but is quite likely to be a new species.

Bluff, W. A. S.; mud flats, Governor's Bay (Lyttelton), Heathcote Estuary, R. M. L.

S. and W. Australia.

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\* Species marked thus have not been included in preceding lists.

**Gracilaria polycarpa** (Harv.?) J. Ag. (1901), p. 89. (= *G. multipartita* (Clem.) J. Ag., var. *polycarpa* Grev.)

East Coast, New Zealand, von Mueller; Blind Bay, Lyall.

Another very doubtful species. Yendo (*Notes on Algae New to Japan*, VI, p. 83) thinks that this, on re-examination, may turn out to be only a form of the variable *Sarcodia montganeana*.

Endemic.

**Gracilaria ramulosa** J. Ag. (1876), p. 417; J. Ag. (1901), p. 70.

New Zealand, Prof. Parker.

This species was identified for N.Z. by Prof. R. J. Harvey Gibson (1893), p. 2, and requires re-identification.

S.-E. Australia.

**Gracilaria secundata** (?) Harv. (1863), *Phyc. Austral. Syn.*, No. 432; J. Ag. (1901), p. 72.

I have forms thus identified by Major Reinbold from Otago Harbour, Moeraki, and Taylor's Mistake (Sumner), but they are quite distinct from the Australian species as identified by Lucas.

S.E. Australia.

#### MELANTHALIA Mont.

In Australasian seas.

(There are undoubtedly two species of this genus in New Zealand, *M. abscissa* in the north and *M. jaubertiana* chiefly in the south, both common on the coast in tidal pools about low water mark. For some reason *M. jaubertiana* recorded in *Fl. N. Zel.*, II, p. 242, was reduced by J. Ag. (1876), p. 404, to a synonym of *M. abscissa*. I do not know whether our form of this species is the same as the Australian.)

**Melanthalia abscissa** (Turn.) Hook. f. et Harv. (1845), p. 548.

From Mangonui southwards to Wellington (N.).

Tasmania.

**Melanthalia jaubertiana** Mont. (1837), *Pl. Cell. Exot.*, p. 136.

Coast of Otago to as far north as Cape Turnagain. I have seen no specimens from further north.

Tasmania.

#### TYLOTUS J. Ag.

In Australian seas.

**Tylotus proliferus** (Harv.) Kylin (1932), p. 60. (= *Calliblepharis*

(?) *prolifera* (H. et H.) J. Ag.)

From Lyttelton north to the Bay of Islands, usually in the drift; not common.

Endemic.

## Family RHODOPHYLLIDACEAE.

## CRASPEDOCARPUS Schmitz.

Endemic genus.

**Craspedocarpus erosus** (Harv.) Schmitz (1897), Engler und Prantl's *Pflanzenfamilien*, Teil 1, Abteilung 2, p. 375.Foveaux Strait, Lyttelton, Lyall; as *Calophyllis erosa*.

Bluff to Bay of Islands, Berggren.

Common in drift from Foveaux Straits to Bay of Islands.

## RHODOPHYLLIS Kuetz.

In most temperate seas.

The New Zealand species were last revised by Dr Cotton (1907), and his results are given here. It cannot, however, yet be said that the species are successfully discriminated. *R. membranacea* is a complex of forms, and *R. lacerata* is very imperfectly known. *R. (?) angustifrons* is quite possibly a form of *R. lacerata*.

**Rhodophyllis acanthocarpa** (Hook. f. et Harv.) J. Ag. (1876), p. 364.East coast and Port Cooper, Lyttelton, Lyall as *Calophyllis acanthocarpa*.

Apparently not uncommon as far north as the Bay of Islands. St. Paul, New Amsterdam.

**Rhodophyllis (?) angustifrons** Hook. f. et Harv. (1855), 2, p. 247.

Bluff and Wellington, Lyall.

I have specimens from Governor's Bay (Lyttelton) that may belong to this species or possibly even to *R. lacerata*, but have not so far examined them minutely.

Kerguelen, Australia.

(*Rhodophyllis chathamensis* Cotton (1907), is *Craspedocarpus erosus*.)

**Rhodophyllis gunnii** Harv. (1845), p. 540.

Chalky Bay and Preservation Harbour, Lyall; The Nuggets, Gore Bay, R. M. L.

I have only a few specimens.

**Rhodophyllis lacerata** Hook. f. et Harv. (1855), 2, p. 247.

Port William, Lyall.

I have a number of specimens from Otago Harbour, Akaroa, and Governor's Bay (Lyttelton) corresponding with a form thus identified by Cotton.

**Rhodophyllis laingii** Cotton (1908), *Kew Bull. Misc. Inform.*, 3.

This was described from a solitary specimen. I have a number collected at the same time and place as the type, and doubt if it is distinct from *R. acanthocarpa*.

**Rhodophyllis membranacea** Harv. (1845), p. 448.

East Coast, Colenso; Cook's Straits, Lyall; Foveaux Straits, Wellington, R. M. L.

Southern Australia, Tasmania.

## Family HYPNEACEAE.

## HYPNEA Lmx.

In most warmer seas.

**Hypnea musciformis** (Wulf) Lmx., 1813, p. 43; Hooker (1867), p. 689.

A species of *Hypnea* exists in New Zealand which has usually been termed *H. musciformis*, but so many different forms have been included under this species that I hesitate to identify it definitely. This is undoubtedly similar to the European forms I have seen. The type locality is the Mediterranean.

Tauranga, Berggren; Bay of Islands, V. W. L.

Widely distributed.

## Family PLOCAMIACEAE.

## PLOCAMIUM (Lmx.) Lyngbye.

On all coasts.

It is hopeless trying to get order into this genus without type specimens and a large series of local examples. Some of the forms pass into each other.

**Plocamium abnorme** (Harv.) 1845, p. 543.

Probably quite a good species. This is one that Yendo wishes to include in *P. telfairiae* (v. under *P. brachiocarpum*). I have a Japanese specimen collected by Higashi and labelled *P. abnorme*, but it is quite distinct from the *P. abnorme* of N.Z. *P. abnorme* is a densely tufted low-growing species, distinct in habit from the other N.Z. species.

Kaikoura, R. M. L.; Lyall's Bay, Berggren; Bay of Islands, Cunningham.

Probably not uncommon, but easily overlooked.

New Zealand, Chathams. Probably endemic.

**Plocamium angustum** J. Ag. (1841), p. 10; (1876), p. 343.

(v. under *P. brachiocarpum* for comment by Yendo. This, however, appears to me to be our most abundant and a very distinct species.)

Common along the coasts.

N.Z., Chathams, Tasmania and Southern Australia.

**Plocamium brachiocarpum** Kutz. (1849), p. 1885.

Yendo (*Notes on Algae New to Japan* (1915), III, p. 111), after a study of the types, proposes to reduce *P. brachiocarpum*, *P. abnorme*, *P. angustum*, *P. recurvatum* to the one species *P. telfairiae*. I quite admit that it is probably true as he states, "All the gradations to link these species may be met with in our material"; but it seems to me that it has yet to be proved that the different forms are merely epharmones (*sensu*, Cockayne). So far as I have seen in N.Z. the different types do not intermingle in their habitats. I, at least, prefer to keep them as separate species for the present.

Apparently common.

N.Z., Campbell Is., Aucklands, The Kermadecs.

Endemic (?).

var. *attenuatum* (?) J. Ag. (1877), p. 21.

J. Ag. thinks this variety may be in part the *P. angustum* of various authors, or even *P. dispernum* Harv.

Bay of Islands, Berggren.

**Plocamium coccineum** Lyngb. (1819), tab. 9, var. *flexuosum* Harv.

(= *P. leptophyllum* Kuetz., var. *flexuosum* J. Ag. (1876). p. 339.)

Harvey recognised *P. coccineum* as a N.Z. species. J. Ag. replaced it by *P. brachiocarpum* and *P. leptophyllum*. I do not know enough about the type of *P. coccineum* to give any opinion and follow Yendo (*l.c.*, p. 114) in recognising only the variety for N.Z.

N.Z., Campbell Is., Aucklands, Chathams.

Most temperate seas.

**Plocamium costatum** J. Ag. (1841), p. 10.

Possibly a composite species. Common on the coasts.

N.Z., the Chathams.

Australia, Tasmania, Japan.

**Plocamium cruciferum** Hook. f. et Harv. (1855) 2, p. 246; J. Ag. (1876), p. 345.

I doubt very much whether the plant of J. Ag. is the same as that of Harv. J. Ag. admits that he did not see a specimen of Harvey's plant, and his description of the species disagrees with Harvey's. *P. cruciferum* Harv. may only be a well-developed *P. angustum*. I must leave it at that for the present.

Bluff to Banks Pen., Berggren.

N.Z., Chathams, Aucklands, in one sense or another.

Endemic.

**Plocamium dilatatum** J. Ag. (1876), p. 347.

Dusky Bay, Forster; Dunedin, Berggren.

I have seen no specimens that I can definitely assign to this species.

N.Z., Tasmania.

**Plocamium dispersum** Hook. f. et Harv. (1855), 2, p. 246.

Foveaux St. northwards to Hawke's Bay.

Not common.

Endemic.

\***Plocamium hookeri** Harv. (1845), p. 257; J. Ag. (1876), p. 337.

Macquarie Is. (identified by Reinhold) (S.), Kerguelen Land and other sub-antarctic islands. The type is from Kerguelen Land.

**Plocamium leptophyllum** Kuetz. (1849), p. 885.

A common species from the South to Wellington. The type is from Tasmania. Lucas (*Algae of Commonwealth Bay*, p. 14) considers this as only a form of *P. coccineum*.

Australia, Tasmania, Antarctic.

var. *recurvatum* J. Ag. (1876) p. 339.

Kaikoura, R. M. L.

N.Z., Tasmania (according to J. Ag.).

(Yendo, *l.c.*, p. 114, states, "*P. leptophyllum* in J. Ag.'s sense has often the definite branches curved downward. *P. hamatum* J. Ag. is nothing but such form which has this sort of branch markedly pronounced." *P. hamatum* is a species of Norfolk Is., also identified by A. H. S. Lucas from Lord Howe Is. I have a specimen from each island. Both are quite distinct from *P. leptophyllum* f. *recurvatum*.)

**Plocamium procerum** J. Ag. (1841), p. 10; Hook. f. et Harv. (1855), p. 695.

Foveaux Str., R. M. L.

N.Z., Lyall.

The type is from Australia, and I doubt whether the N.Z. form is the same as it, but I have only seen one or two specimens from N.Z., and these are not very certain.

#### Family SPHAEROCOCCACEAE.

##### PHACELOCARPUS Endl. et Diesing.

South Africa, Australia, and New Zealand.

**Phacelocarpus alatus** Harv. (1855), *Trans. Ir. Acad.*, vol. 22, p. 549.

Southern Otago, R. M. L.; Bay of Islands, V. W. L.

Not common.

S. Australia.

**Phacelocarpus labillardieri** (Mert.) J. Ag. (1852), p. 648.

Sub-littoral, common along all the coasts.

N.Z., Australia, Tasmania.

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\* Species marked thus have not been included in preceding lists.

## APOPHLAEA Harv.

A curious endemic genus, of quite uncertain position;  
possibly should be placed in the Gelidiales.

**Apophlaea lyallii** Hook. f. et Harv. (1855), 2, p. 24.

Sporadically common along the coasts, near high water mark.  
The Chathams, N.Z.  
Endemic.

**Apophlaea sinclairii** Harv. (1855), 2, p. 244.

In similar positions to the preceding, but less common.  
Campbell Is., Stewart Is., Snares, N.Z.  
Endemic.

## GELIDIOPSIS Schmitz.

Widely distributed in temperate and sub-tropic seas.

**Gelidiopsis rigida** (Vahl) Weber v. Bosse (1914), p. 9. Rhodophyc. Percy Sladen Expedition.

This has been recorded from N.Z. by Gruenow, *Novara Exped.*, p. 80, but requires microscopic investigation for re-identification.

## Family SOLIERIACEAE.

## THYSANOCCLADIA Endlicher.

**Thysanocladia laxa** Sond. (1852), *Linnaea*, vol. 25, p. 689.

The type is from S. Australia (Rivoli Bay).

The species was identified for N.Z. by Reinhold from specimens collected by me at Foveaux Straits, but more material is wanted for fuller identification.

N.Z., Southern Australia.

## SARCODIOTHECA Kylin.

N.Z., N.-W. America (Pacific Coast).

**Sarcodiotheca colensoi** (Hook. f. et Harv.) Kylin (1932), p. 16;  
*Prionitis colensoi* H. et H.; *Vidalia colensoi* (H. et H.)  
J. Ag.

Cape Turnagain, Colenso; Anawhata, L. M. C.; Bay of Islands,  
V. W. L.; Hokianga, Berggren (N.).

Endemic. (? Japan, Yendo.)

## Family SARCODIACEAE.

## CARPOCOCCUS J. Ag.

Canaries, Red Sea, Indian Coasts, and N.Z.

**Carpococcus** (?) **linearis** J. Ag. (1876), p. 586.

The specimens are sterile, and the species of very questionable position; v. Kylin (1932), p. 57.

The Chathams, Travers.

Endemic.

**SARCODIA** J. Ag.

Indian and Australasian seas.

**Sarcodia montagneana** J. Ag. (1852), p. 623.

Wellington Heads to Mangonui (N.).

Low tide rocks and pools.

N.Z., Chathams.

S. Georgia, Australia, Japan.

**TREMATOCARPUS** Kuetz.

S. America, N.Z.

**Trematocarpus (Dicranoma) aciculare** J. Ag.; Kylin (1932), p. 54.

Warrington, type-locality. As N.Z. workers are still in some doubt as to the identity of this species, though it is, perhaps, common, other localities are not here given.

Endemic.

**Family MYCHODEACEAE.**

**MYCHODEA** Harv.

In Australasian Seas.

**Mychodea foliosa** (Harv.) J. Ag. (1876), p. 573; De Toni et Forti (1923), p. 18.

Port Chalmers, Capra.

I have seen no specimen.

N.Z., Australia S.

**Family RHABDONIACEAE.**

**ARESCHOUGIA** Harv.

In Australasian Seas.

**Areschougia laurencia** Hook. f. et Harv. (1847), p. 409.

Lyall Bay, R. M. L.; Bay of Islands, V. W. L.

Identified for N.Z. by Reinbold, but I am not sure that it is the same as the Australian species.

N.Z., Australia S. and W.

**CATENELLA** Grev.

An almost cosmopolitan genus.

**Catenella fusiformis** (J. Ag.) Skottsb. (1923), p. 13; v. also Post,

*Rev. Algol.* (1936), Tome 9, 36, pp. 1-84.

Occasionally found on rocks, on piles of wharves, but particularly on the pneumatophores of mangroves.

Puketeraki to the Bay of Islands.

N.Z., Fuegia to Chili.

\***Catenella nipae** Zan. v. Post, *l.c.*, p. 68.

In previous lists this wrongly appears as *C. opuntia* (Good. et Wood.) Grev.

Very often on the pneumatophores of mangroves, associated with *Bostrychia* sp. and *Caloglossa*.

Nelson to Hokianga and Bay of Islands.

N.Z., Australia, New Guinea, and through the Malay Archipelago to Burmah.

#### Family DICRANEMACEAE.

**DICRANEMA** Sond.

In Australasian Seas.

**Dicranema grevillei** Sond. (1845), *Bot. Zeit.*, p. 56.

Foveaux St., Kaikoura (drift), R. M. L.

This species rests on few specimens of questionable identity; so named by Reinhold.

S. and E. Australia.

#### Family PHYLLOPHORACEAE.

**AHNFELTIA** Fries.

A genus of somewhat uncertain position, widely distributed in temperate and colder seas.

**Ahnfeltia furcata** (Hook. f. et Harv.) J. Ag. (1876), p. 208.

Not uncommon along the coasts, from Riverton to the Bay of Islands.

Endemic.

**Ahnfeltia torulosa** (Hook. f. et Harv.) J. Ag. (1876), p. 207.

*Gymnogongrus furcellatus* Harv. partim.

Bay of Islands, Berggren.

If I have rightly identified it, to be found along the coasts, from the extreme south to Wellington.

N.Z., Snares, Campbell Island (S.). Endemic.

#### Family GIGARTINACEAE.

**GIGARTINA** (Stackhouse) J. Ag.

Widely distributed.

The genus has been revised for New Zealand by Laing and Gourlay, *Trans. N.Z.I.* (1929), pp. 102-135; (1931) pp. 134-155.

These papers should be consulted for further information.

**Gigartina alveata** J. Ag. (1851), p. 271.

N.Z. (N.).

A purely northern species. I have seen no specimens from further south than Raglan on the W. Coast and the Great Barrier on the East.

Endemic.

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\* Species marked thus have not been included in preceding lists.

**Gigartina ancistroclada** Mont. (1845), *Voy. Pole Sud*, t. 7, fig. 4.

Akaroa D'Urville.

This species does not appear to have been found since its discovery, nearly a century ago. The plant described by Lg. and Gy. (1929), p. 129, is distinct, and, perhaps, a new species. This has been definitely determined by subsequent comparison with a fragment of one of Montague's specimens. The Australian plant which goes under the name *G. ancistroclada* is also different from the original and distinct from any N.Z. form I have seen. Lyall is said by H. et H. to have collected the species in Otago, but this is at least questionable.

Probably endemic.

**Gigartina angulata** J. Ag. (1876), p. 197.

N.Z., Stewart Is., Chathams (S.).

This is a common South Island species, and occurs as far north as Lyall Bay.

Endemic.

**Gigartina apoda** J. Ag. (1899), p. 31.

Stewart Island to Wellington Heads.

N.Z., Chathams (S.).

Endemic.

**Gigartina atropurpurea** (J. Ag.) 1885, p. 31.

Banks Peninsula to Bay of Islands; not uncommon on low-tide rocks.

Endemic.

**Gigartina chapmanii** (Hook. f. et Harv.) 1855, p. 251, T. ii9B.

Maketu, Chapman; Banks Pen., R. M. L.; Tauranga, Berggren (?).

Apparently a rare sub-littoral species. There are several allied forms not yet well identified.

**Gigartina circumcincta** J. Ag. (1876), p. 202.

This includes some of the forms previously identified as *G. radula* J. Ag.

Common along the East Coast on open, rocky shores.

Endemic (?).

**Gigartina clavifera** J. Ag. (1876), p. 194.

A common species in one form or another, but becoming rarer towards the North. However, I have seen specimens from as far N. as Waikato Heads.

Endemic.

**\*Gigartina cranwellae** sp. ined.

This replaces *G. chauvinii* J. Ag., *Fl. N.Z.*, vol. 2, p. 252. *G. chauvinii* is a species of the West Coast of South America which does not, I am satisfied, occur in New Zealand.

*G. cranwellae* occurs in many forms in the northern part of the N. Island, but becomes less common as one goes south.

N.Z. (N.).

Endemic.

**Gigartina decipiens** Hook. f. et Harv. (1855), p. 547.

On open rocky coasts, as far N. as Wellington.

N.Z., Chathams (S.).

Endemic.

**Gigartina divaricata** Hook. f. et Harv. (1845), p. 75.

Snares, Auckland, Campbell Is. (S.).

J. Ag. gives *G. divaricata* as found by Berggren at the Bay of Islands, possibly confusing some other species with it.

(*Gigartina flabellata* J. Ag. sp. *exclud.* I have seen a set of Tasmanian forms of this species. They do not correspond with any N.Z. forms that I have seen, and I consider the species should be removed from our lists.)

**Gigartina grandifida** J. Ag. (1876), p. 199.

This species was excluded by Lg. et Gy. (1931), p. 143, but may have to be restored and redescribed. The original description was based on two specimens from the Chathams. There is, however, a species abundant on many parts of the E. coast of N.Z. which, on the whole, agrees with J. Ag.'s description, but that description is too narrow and, in places, not satisfactory. Until, however, the whole series of forms is re-investigated, the species had better be left to stand.

The Chathams, Travers.

**Gigartina insidiosa** J. Ag. (1899), p. 22.

No locality is given by Agardh for this species, but as he previously referred it to *G. pinnata* (*G. livida*), it must belong to either N.Z. or Australia, or to both. This species has not yet been re-identified.

**Gigartina kroneana** Rabenh. (1878), *Flora der Auckland Inseln*, Hedwigia, 17, p. 70.

Aucklands, Campbell Is. (S.).

Endemic.

**Gigartina laciniata** J. Ag. (1876), p. 197.

Chathams (J. Ag.).

I have seen no specimens.

Endemic.

\* Species marked thus have not been included in preceding lists.

**\*Gigartina laingii** sp. ined.

Bay of Islands, V. W. L., and elsewhere in N. Auckland.

Endemic.

**Gigartina lanceata** J. Ag. (1899), p. 29.

From Otago Pen. to Kaikoura (S.).

N.Z., Australia. (I have seen no Australian specimens.)

**Gigartina livida** (Turn.) J. Ag. (1851), p. 270; *G. pinnata* Harv., *Phyc. Austr.*, pl. 68.

An imperfectly identified species in N.Z., but, perhaps, widely distributed; not common.

Riverton, Wycliffe Bay, R. M. L.; Poroa, Otago, and Jackson's Bay, Lyall; Portobello (Otago Harb.), W. A. Scarfe.

Tasmania, S. Australia.

**Gigartina longifolia** J. Ag. (1899), p. 36.

Otago Peninsula to Kaikoura, R. M. L.

Endemic.

**Gigartina macrocarpa** J. Ag. (1876), p. 683.

Wellington to Bay of Islands, in many forms; but much more common in the north (N.).

**Gigartina marginifera** J. Ag. (1876), p. 122, v. Lg. et Gy. (1929), p. 122.

Foveaux Straits to Bay of Islands.

A puzzling plant, only occasionally found, and possibly a hybrid.

Endemic.

**Gigartina polyglotta** J. Ag. (1885), p. 29.

Lg. et Gy., *T.N.Z.I.* (1929), p. 123, state: "We have seen no specimens which we can definitely assign to this species." I have since collected it at Makara and at other places in Cook Strait. The three lower figures in Fig. 42, *G. decipiens* (*loc. cit.*) tsp., probably belong to this species.

Endemic.

**Gigartina protea** J. Ag. (1885), p. 29.

*G. protea*, *G. decipiens*, and *G. polyglotta* might readily be described as variants of one species, though in extreme forms they are clearly distinct, yet they pass into each other by many intermediates. They may quite well be local habitat forms.

*G. protea* is chiefly known from Lyttelton to Wellington, and is usually a dominant species on the Gladstone Pier, Lyttelton.

Endemic.

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\* Species marked thus have not been included in preceding lists.

**Gigartina tuberculosa** Hook. f. et Harv. (1847), p. 188.

Auckland Islands, the type locality (S.).

Reported also from Peru, Chili, and Fuegia, but the S. American plant is doubtfully identical. Somewhat similar forms may be found at Stewart Island and Dunedin; but the species requires fuller description and better identification from a larger series of specimens.

#### GYMNOGONGRUS Mart.

**Gymnogongrus nodiferus** (Hook. f. et Harv.) J. Ag. (1876), p. 210, note to *G. furcellatus*.

Bluff to Bay of Islands; common on the coasts.

Endemic.

I have several other forms, apparently belonging to this genus, but hesitate to introduce them without further examination and description. Amongst them is what may be *G. vermicularis* (Turn.) J. Ag.; but as I doubt the identity of Agardh's plant with Turner's, I leave it at present amongst our *species inquirendae*. However, specimens collected by L. M. C. at Anawhata (Auckland) correspond closely to some collected at Sea Point, Cape of Good Hope.

#### STENOGRAMMA Harv.

**Stenogramma interrupta** (C. Ag.) Mont. (1846) in Duchartre's *Rev. Bot.*, p. 483.

According to Colenso, common along all the coasts. It seems to me rather sporadic, though I have seen specimens from points as far apart as Dusky Sound and the Bay of Islands.

A very widely distributed species in temperate and warmer seas.

#### IRIDOPHYCUS Setchell and Gardner.

In most temperate seas.

In 1937 Setchell and Gardner, *University of California Publications in Botany*, vol. 19, no. 6, discarded the genus *Iridaea*, placing its species in the new genus *Iridophycus* or in other genera. They further state that in the "Australio-New Zealand region" there appear to be about 2 species of *Iridophycus* and 6 of *Rhodoglossum* (l.c., p. 198). The genus *Iridaea* as it stood was too vague and ill-defined to be identifiable, but until a thorough investigation of the New Zealand forms is made a purely tentative list can only be drawn out.

**Iridophycus laminarioides** Setch. et Gard. (l.c.)

The type locality is on the island of Chiloé, off the coast of Chili, where it was collected by Dumont D'Urville, and S. et G. (l.c., p. 208) consider this the only certain locality. However, a plant also collected by D'Urville at Lord Aucklands Group has.

been referred by subsequent observers to this species. Its identity with the S. American plant is very questionable. Another species of *Iridophycus* which has been recorded in New Zealand is *Iridaea cordata*. This again has been confused with *I. micans*. Setchell (*l.c.*) states the "combined nomenclature is so much confused that it seems undesirable to attempt to unravel it," and considers that for the present, at any rate, it would be wise to retain the specific name *cordatus* for the boreal species of *Iridophycus*, to which it was originally attached by Turner in his *Fucus cordatus*. (v. also Skottsberg (1923), *Rhodophyceae der Schwedischen Expedit. nach Patagonien*, p. 6.)

(What *Iridaea lanceolata* Harv. (1855), p. 252, really is no one knows. J. Ag. (1876), p. 201, associated it with *Gigartina fissa*. The type is, I think, at Kew. It was originally collected by Lyall in Otago, and until a wide range of specimens is collected and compared with the type the species must be left in abeyance.)

#### RHODOGLOSSUM J. Ag.

*Rhodoglossum latissimum* (Hook. f. et Harv.) J. Ag. (1876), p. 187.

Timaru, Akaroa, Lyall Bay, R. M. L.

N.Z., Aucklands, Campbell Is., Australia, and N.W. America.

I have seen no American specimens, and therefore do not know whether they are the same as ours. Harvey *Fl. Ant.*, t. 73, f. 1, described it as *Halymenia latissima*, and the types are from the Auckland and Campbell Islands. Gruen (1870), *Alg. Novara*, p. 69, t. IX, figs. 3a-d, placed it in the genus *Iridaea*.

#### ADDITIONAL CITATIONS.

The bulk of the literature dealing with the New Zealand seaweeds will be found listed in Laing (1926), *A Reference List of New Zealand Marine Algae*, which should be consulted in conjunction with this paper. These references, for the sake of brevity, are not repeated here. Only additional citations are now recorded. In a few cases such additions will be found in the text alone, when the reference is used only once, and consequently is more conveniently placed there.

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## The Birth, Growth and Death of a Legend.

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G. BLAKE PALMER, M.R.C.S., L.R.C.P. (Lond.), D.P.M.

ALL legends have a beginning, usually a simple one, then pass through a phase of active elaboration, and at some stage of their existence, gain an actual belief among many of those through whose minds and mouths they pass.

Legends must also have a focus around which is built up the more elaborate body of their maturer form. This starting point need not of necessity be in the activities of an historical figure. Often the legend attaches itself to some mythological figment, called into being by the projection of early peoples' striving to give outward expression to inner doubts and desires or trying to explain some natural phenomenon in figures of their own understanding.

Legends at all stages, and even during their decline, are always attracting extraneous elements and matter to themselves, often absorbing other legends within their former framework. Once started, they grow apace, changing their form and hiding their origins beneath a mass of later accretions until the true matter of their origin is completely obscured, at least to the casual observer and collector of tales. The locations of the chief incidents or the name and nationality of its hero may change with remarkable facility. A legend cannot be properly said to die, otherwise we should have no knowledge of it, but at some stage of its existence it may forfeit that vital element of belief which enabled it to grow and flourish. Many forces may tend to perpetuate or stimulate the factors of belief—nationalistic pride and prejudice, political and ecclesiastical support, or in its more decadent day, the services of the pseudo-historian, of the bard, the writer of romances, or even the composer of grand opera. The legend may be kept alive by local folk-lore and customs, or it may even be aided in its survival by influences as diverse as the over-zealous antiquary securing his material by attentive visits to the local inn, and the tourist agency which advertises the legend for its own profit. Finally, the daily and weekly press, which delights to fit every archaeological discovery into the exploits of some well-known legendary hero, at least implies a persistence of pseudo-historical belief.

Legends vary in their capacity for growth, but those of the heroing, especially if he has led an ultimately losing cause, are perhaps those whose growth is most luxuriant and whose form changes continually as they pass from simple beginnings to their decadence, whether in the remote past or in the romantic movement of the nineteenth century. They have much in common, and within a few decades of their inception all begin to attract elements from the current legendaries of their own and neighbouring peoples. It is

discussed in this paper. There are many such heroes, each with his cycle of legend. Some, like Alexander and Charlemagne, have remained more historical and less stirring in the imagination of the people than others, the leaders of lost causes, like Roland and Arthur. Let us consider King Arthur.

Arthur, of course, was not a king, and many have even flatly denied his human existence. He has recently been taken as a type-species of the mythical hero,<sup>(1)</sup> as a survival of a Celtic god Artaios,<sup>(2)</sup> as a proof of Welsh and Bretons' mendacity; in fact, many of those who cannot accept an historical mention for him offer proofs which outbid the wildest legends in their improbability. Some have denied him on the ground of the silence of certain distant contemporary and early authorities; but on precisely analogous grounds one might deny the existence of St. Patrick himself, whose earliest extant documentary record dates from two centuries after his death.<sup>(3)</sup> But this discussion is out-of-place. It may be affirmed with reasonable certainty that there was an historical Arthur who, at the turn of the fifth century, raised a body of heavy-armed cavalry—a mobile field force modelled on similar Roman troops of the fifth century—and used them against the Saxon invaders of Britain.<sup>(4)</sup>

His progress can be traced in history, legend and folk-lore in Greater and Lesser Britain, until with the advent of Geoffrey of Monmouth's *Historia* in the mid-twelfth century, he entered upon a literary career with which this paper has little concern. The progress of King Arthur throws many important sidelights upon the genesis of a legend, especially upon the extraordinary changes in form and content that it and associated folk-lore can undergo. Its examination should provide salutary lessons to many who theorise upon the meaning of legends without inquiring into their earlier forms. A similar error has been responsible for much place-name nonsense until quite recent times.

The starting point or hero of a legend is relatively unimportant in determining its ultimate form—the historical background of its earlier years greatly influences future development. Especially is this the case with King Arthur, whose times are even now wrapped in such mystery and historical uncertainty that the date of what is said to be his greatest victory cannot be placed closer than between the limits of 493 and 516 A.D.<sup>(5)</sup> A passing glance at the state of Britain, especially western Britain, in the fifth century is not out of place.

The records of the period are mainly archaeological, poorly supported by a sole contemporary witness who, unluckily, was not an historian, but a monk most anxious to prove that the manifold suffering of his fellow countrymen could be traced to their neglect of spiritual affairs. Gildas the Wise, who was born in the year of Badon, tells us:

“If there were any records of my country they were buried in the fires of the conquest, or carried away on the ships of the exiles. so that I can only follow the dark and

Britain, long harassed by Saxon, Irish and Pictish pirates, had been granted autonomy by Honorius in 410 A.D. The cities of the Romanized south-east undertook local defence, and government on a cantonal basis existed. By 450 A.D., they were hopelessly disorganised, and the more vigorous Celtic kingdoms of the west who had enjoyed autonomy and even their own militia under the Roman rule, exerted an overlordship over the more decadent but Romanized citizens. The Celtic backwash, which reached even to Kent, provided a rough but strong government, and Britain, according to contemporary writers like St. Patrick and St. Germanus, was still prosperous.<sup>(7)</sup> In about 450 A.D., a Celtic King, Guorthigern, called in Saxon *foederati* to assist him in a local campaign.

“ They land first on the eastern side of the island, by the orders of the unlucky King of Britain, and fix their horrid claws therein, nominally about to fight in defence of our country, but more really for its destruction. Their motherland, learning of the success of the first band, sends over in more numerous companies these dogs of mercenaries, who come across on their ships to unite with their base-born comrades. From that time the seed of iniquity, the root of bitterness was planted among us, and the poisonous growth, as we deserved for our demerits, sprang up on our soil with rank-growing stalks and leaves. The barbarians, introduced among us as our soldiers and ready (as they falsely boasted) to brave every danger in behalf of their worthy hosts, ask for regular pay. It is given, and for some time stops, as the proverb goes, the dog’s maw. Presently, however, they complain that their monthly wages are not supplied in sufficient quantity, deliberately making out a colourable case against their employers, and say that more profuse maintenance must be given, or they will break their agreement and ravage the whole island. Nor is there long delay; the threat is followed by its execution. For the conflagration that started in the east, the due punishment for our previous sins, was spread from sea to sea, fed by their sacrilegious hands; it blazed across every city and region, nor did it stay its burning course until after devastating almost the whole surface of the island, its ruddy tongues licked the western ocean.” (Gildas: *De Excidio et Conquestu Britanniae*, chap. 23.)

They were aided by their compatriots penetrating along the waterways of Eastern Britain, and at the turn of the sixth century a determined effort was made by the Celtic Kings to evict these Saxon intruders. Numerically and in equipment, the Celtic West was stronger than its aggressors, but was hopelessly divided amongst itself in civil war between its many states. Nominally Christian, boasting some men whose asceticism has seldom been surpassed (the Monks of Menevia even yoked themselves like oxen to the plough), possessing a rapidly declining knowledge of Latin,<sup>(8)</sup> rhetoric and

rulers of the west were hotbeds of intrigue, vice and oppression, and their scandals have come down to us to-day in the pages of Gildas, where they await discovery by some astute director at Hollywood.

The Saxons, inferior in numbers and equipment, profited by the civil strife of their opponents and commenced their invasion with a series of raids, so vividly described by Gildas:

"Every colony is levelled to the ground by the stroke of the battering ram, the inhabitants are slaughtered along with the guardians of their churches, priests and people alike, while the sword gleamed on every side, and the flames crackled around. How horrible to behold in the midst of the streets the tops of towers torn from their lofty hinges, the stones of high walls, holy altars, mutilated corpses, all covered with livid clots of coagulated blood, looking as if they had been crushed together in some ghastly wine-press!

"And there was no grave for the dead, unless they were buried under the wretched ruins of their homes, save the bellies of birds and beasts of prey—with reverence, be it spoken, of the blessed souls (if indeed there were many found) which were carried at that time by the holy angels to the height of heaven . . . Of the miserable remnant some flee to the hills, only to be captured and slain in heaps; some, constrained by famine, come in and surrender themselves to be slaves for ever to the enemy, if only their lives might be spared—and this was the best that was granted, others wailing bitterly passed overseas." (Gildas: *De Excidio et Conquestu Britanniae*, chap. 24.)

Later they followed with a slow penetration of the Celtic west, which only finally ceased more than a millennium later with the shireing of Wales under Henry VIII.<sup>(10)</sup>

The Britons, however, with all their faults, were more stubborn in resistance than the Continental Gauls, and late in the fifth century there arose two leaders, around one of whom has grown up the whole cycle of Arthurian legend.

The Celtic civil strife had halted about 467 A.D. with the suppression of Guitolinus by Ambrosius Aurelianus,<sup>(11)</sup> and they made considerable headway against the invaders. A period of alternating fortunes followed—

"down to the year of the siege of Mount Badon, which lies near the mouth of the Severn, the year of the last and not the least slaughter of these ruffians, which was the forty-fourth (as I know) with one month elapsed, since it was also the date of my own nativity. But even now our cities are not inhabited as they were of yore, but lie in ruins, deserted and wrecked, our foreign wars having ceased, but not our civil strife."<sup>(12)</sup>

It is obvious that the leader who united the warring Celtic kingdoms against the Saxon invaders was just such a figure as would attract legend, hero-worship and tales of the miraculous. This process, slow at first, was accentuated by the well-attested and traditional

tendencies of the Welsh away from verbal exactitude. It was intensified by their Bardic organisations and above all by the renewed attacks on Celtic independence in the ninth, tenth and twelfth centuries. Plain facts were embellished into glorious fictions, brave warriors became great heroes, and Arthur, not even a petty king in the sixth century, grew into a valorous warrior in the eighth, and having early caught the glowing colours of a hero of romance, by the twelfth century had become emperor of the whole civilised world.

Let us consider first the plain facts. Gildas, a contemporary, born in the year of Mount Badon and writing before 547 A.D., gives the outline and mentions the battle, but does not directly name Arthur; Bede, copying Gildas, is also silent on the name. The first mention of Arthur by name, but in the same context as Gildas' Badon story, is in the early ninth century *Historia Brittonum* of Nennius. It is conceded by many that this contains traces of an earlier seventh century annal written perhaps by Rum Map Urbagen, later St. Paulinus (?). In any case, the earliest manuscript—that of Chartres<sup>(13)</sup>—was compiled before the 1st January, 801 A.D.

Here we are told how: "In those days Arthur fought against them. He fought with the Kings of the Britons and was their leader in war (sed ipse dux erat bellorum). He first fought at the mouth of the waters of the Glein, the second, third, fourth and fifth battles were on another river Dubglas, in the country of Linnuis; a sixth was fought on the river Bassas, a seventh in Cat Coit Celidon, a battle in the wood of Celidon, an eighth at the castle of Guinnion, where he carried on his shoulders an image of the Blessed Virgin Mary, and on that day the pagans, put to flight, lost many killed through the aid of our Lord Jesus Christ and of the Blessed Virgin his Mother. A ninth battle was at Cair Legion, a tenth at the Tribruit, an eleventh at Mount Agned, and the twelfth was fought in Mount Badon, where 960 men fell to the single onslaught of Arthur ('s men) and he alone fought against them. And in all these battles Arthur was victorious."<sup>(14)</sup> <sup>(15)</sup>

Another, somewhat later compilation, the *Annales Cambriae*, dating from the tenth century, gives these entries:

"An. LXXII (i.e. 516 A.D.). The battle of Badon in which Arthur bore the cross of our Lord Jesus Christ for three days and three nights on his shoulders and the Britons were victorious. (Note the transfer of the legendary interest from one battle to another). An. XCIII (i.e. 537). The battle of Camlann in which Arthur and Medraut fell."

Here we have not later than the year 954 A.D. Arthur associated with the name of Medraut, the Sir Mordred of the Romances. How much earlier the two were associated it is hard to say.

The tenth century yields little else to supplement the tale of Arthur save an interpolation in one of the South Wales genealogies, now provedly unreliable.

But returning to the *Historia Brittonum*, Arthur is met in a guise which was carefully suppressed by Geoffrey of Monmouth, and on which the Romances are silent. He appears as the legendary huntsman of the "Pig Troynt"—the Twrch Trwyth in the later story of *Kulhwch and Olwen*, and we get our earliest glimpses of him in his capacities of the leader of the Hell rout, the Harrier of Hades (which by contemporaries was held to be located in Ireland), the magic huntsman, and the many strange and purely mythical associations which are so commonly attributed to him in the bardic literature and folk-lore.

Perhaps it would be well to depart from chronological order and relate in some detail the fuller development of the Celtic Arthur before the Romances changed his character beyond recognition. But before discussing these new legendary associations, a short digression is permissible to consider the tendency, already noticed in Nennius, for miraculous and legendary qualities to attach themselves to the hero-leader. This process, common to all hero legends, is admirably summarised by Lord Raglan, and though, of course, he is discussing the hero of myth, his generalisation applies. I think, to all legends of the hero-king type.<sup>(16)</sup>

- (1) "The person with whom legends (myths) are associated must not be too recent, or the true facts of his career will be remembered, or too remote, or he will have been superseded or forgotten. About fifty years after his death is a probable time for legend (myth), but this may be extended if his career has been recorded and his fame has not been eclipsed by a latecomer of similar character," as with King Arthur, who had no immediate successful followers in Celtic Britain.
- (2) "He must have been famous or notorious in certain definite connections and his exploits or misfortunes must be such as to afford pegs upon which legend (myth) can be hung." The absence of Arthur's tomb is such a peg.
- (3) "The miracles which the legend (myth) contain will be attributed to the historical character if, when the legends (myths) are first attached to him, the possibility of such miracles is still believed in, otherwise they will be omitted," as later writers like Geoffrey of Monmouth, Wace and others omitted all references to King Arthur's association with the Hell-rout and Twrch Trwyth, yet permitted him to do battle with serpents. A similar tendency is noted in comparing the older and more recent *Vitae Sanctorum*. The progress of Arthur fits the scheme admirably.

A fourth point could perhaps be added to emphasise the tendency for any well-known popular hero to displace the names formerly associated with some other legendary or allegorical story. For example, in the earlier Welsh tradition, Cai, the Sir Kay of the Romances, fought with Palug's cat on Mona. The story is later told of Arthur. A reverse tendency is found elsewhere; for example, Arthur's somewhat undignified fight with a hog is glossed over or attributed to his followers.

To return to the progress of Arthur: Nennius' passage is short and occurs in connection with certain *Mirabilia* of South Wales. Here we meet the earliest recorded Arthurian place names (in what are now the shires of Brecknock and Hereford).

"There is another marvel in the district called Buelt. Here is a pile of stones and on the top of the heap is a single stone with the footprint of a dog on it. When they hunted the Pig Troynt, Cabal, who was the dog of the warrior Arthur, set his footprint on the stone, and Arthur after made a heap of stones beneath the stone in which the dog's footprint was and it is called Carn Cabal." Cabal, in all probability, was originally Arthur's horse, as he is in folk-tales.<sup>(17)</sup>

"There is another marvel in the district which is called Ercing. Here is a burial place beside a well which is named Licat Anir, and the name of the man who was buried in the place was named Anir. He was the son of the warrior Arthur . . ." And the story goes on to say that the mound is of different length wherever measured.

On a recent visit to Cefn Carn Caval south of Rhayader Gwy, a cairn has been found answering the description,

"and on it is a stone about two feet in length and not quite a foot in width in one side of which there is an oval indentation about two inches deep. On a brief inspection this might be imagined, without any great strain, to be the print of a dog's foot; but if it is closely examined it will be observed that whilst there is a faint tracing of the ball of the foot, the divisions of the toes and positions of the claws is not marked."<sup>(18)</sup>

King Arthur was the huntsman of several magic pigs, some of which left blessings of fertility and crops in their tracks. The character of such stories is obvious, but the great hunt deserves further mention and will serve as an example. The hunting of the Pig Troynt is described in very great detail in one of the stories of the *Mabinogion*, "*Kulhwch and Olwen*."<sup>(19)</sup> In its present form it is purely Celtic in spirit and probably shows the most highly developed native Arthurian legend before the influence of Geoffrey of Monmouth's *fabulosa historia*.

In *Kulhwch and Olwen*, which in its present form dates probably from the early twelfth century, and contains many precise descriptions of Welsh life, customs, and geography of those times, the bald narrative of Nennius is expanded. The "reasons" and setting of the legendary hunt are told in full. Kulhwch seeks help of King Arthur, his cousin, to assist him to find Olwen, daughter of Yspaddaden, the chief giant. His wish is granted, and the quest begins. Thirty-nine tasks are set, many of which are agricultural, and many more preparatory to the hunting of Twrch Trwyth, between whose ears are the comb and scissors with which to trim the beard of Yspaddaden. Kulhwch ultimately succeeds and marries Olwen.

In the story, Arthur is already the King of a splendid but entirely Celtic court. His gatekeeper relates the story of his conquests and campaigns in Europe, a forerunner of the foreign wars in the Romances. He receives well-born strangers with presents and feasting, welcomes tales of their adventures, and grants their boons unquestioningly. A long list of the members of his court is recited, and in it are met Cai and Bedwyr, Gwenhwyfar and Essyllt, though in a character scarcely recognisable to readers of Malory and Tennyson. Cai and Bedwyr have miraculous powers, and no doubt these "knights" at least represent a personification of older Celtic deities (the moon and lighting).

But to return to the legendary huntsmen and the hunting of *Twrch Trwyth*—surely the greatest of all hunting legends. *Kulhwch* is told by *Yspaddaden*: "There is no comb in the world, or scissors, with which my hair can be dressed because of its stiffness, save the comb and scissors between the two ears of *Tyrch Trwyth*, the son of *Tared Wledig*." He replies, "Easy is it for me to get it, though you think it is not easy."

In the quest which follows Arthur hears that the boar is in Ireland, and sails abroad in *Prydwen* to meet him there, which he did at *Esgair Oerfel*. Here, "Arthur's bodyguard fought with him. Except what evil they had from it they had nothing of good. The third day Arthur himself fought with him nine days and nine nights. He slew none save one little pig out of the swine."

"And the *Grugwyn* threatened to move to Britain."

Arthur followed.

"They set forth by sea towards *Cymru*, and Arthur and his hosts his horses and his dogs, went aboard *Prydwen*, and he cast a glance of an eye on them."

"And *Twrch Trwyth* alighted at *Porth Cleis* in *Dyfed*.\* Arthur came that night as far as *Mynyw*. The next day Arthur was told that they had gone by . . . and they had slain what men and cattle there were in *Deu Cleddyf* before the coming of Arthur."

The hunt ranged with geographical exactitude through *Dyfed*, *Buelt* and *Ercing* and all South Wales. Men, dogs and horses were slain. The hunt started through *Dyfed* to the *Presseleu Hills* (whence came the blue stones of Stonehenge) and across the river *Nyfer*, "and then *Bedwyr* with *Caval*, Arthur's dog, and all the warriors brought *Twrch Trwyth* to bay at *Cwm Cerwyn*." Many men were killed, but the pig escaped. "Thence he went as far as *Glyn Ystiu* and there the men and dogs lost him."

"Then all the huntsmen went to hunt the swine as far as *Dyffryn Llychyr*." "And thence he went to *Ceredigiawnt* . . ." "Twrch Trwyth went thence between the *Tawy* and *Ewyas* . . .

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\* Part of modern county of Pembroke.

† Modern county of Cardigan.

And Arthur said to the warriors of the Island, 'Twrch Trwyth has slain many of my men, not while I live will he go into Cornwall. I will oppose my life to his life. Do what you will.' " And the whole hunt entrapped him by the Severn and secured part of the spoil.

" On one side Mabon the son of Modran spurred his steed and obtained the razor and on the other Cyledyr Wyllt, on another horse, assailed him in the Severn and took the scissors. Before they deprived him of the comb he found the ground under his feet, and neither dog, man nor horse could keep company with him until he went to Cornwall. Thence Arthur and his host went until they had driven him into Cornwall. What evil they had suffered before was play compared with what they suffered getting the comb. From one evil to another the comb was got from him. And thence he was expelled from Cornwall and was driven straight ahead into the sea."

The symbolism of the hunt is varied, and there are many contending interpretations—solar, agricultural and allegorical. Curiously enough, its starting point in Dyfed at Porth Cleis† was the favourite port of the barbarous Irish raiders of the fourth and early fifth centuries. The boar hunt may well represent their invasions and expulsion. The comb and scissors are an obvious symbol of civilisation, only attained when the raiders have been driven away as they were, not by Arthur, but a hundred years *before* his time. Confusion of time, especially of past time, is a characteristic of folklore and folk memory. To the folk, a thousand years are but yesterday. In semi-literate communities, events in the preceding generation have an almost equal value with remote antiquity. For example, when visiting the Church of Boveney, I asked the old cleaner how old it was. There was a memorial tablet commemorating an Elizabethan worthy in this church which she must have looked at every week for forty years, and yet her reply was: "It is very old, sir—over a hundred years I should say." That was in 1928. The church did, in fact, date from the Conquest. There are innumerable examples of a similar lack of a sense of past time in legend.

I now come to what is perhaps the most interesting of all developments in Arthurian story—the legend of the undying Arthur, of the hero resting after his labours and awaiting his recall to save his people and lead the Cymry to victory. This legend was old long before 1125 A.D., and is referred to scathingly by William of Malmesbury. In his *Gesta Regum* we read:

"But the tomb of Arthur is nowhere beheld whence ancient ditties fable that he is yet to come."

Tombs of Arthur's followers had long been known, some even to Nennius. William of Malmesbury mentions:

"the tomb of Walwen, who was the not degenerate son of Arthur by his sister . . . was found in the time of King William upon the sea shore, 14 feet in length . . ."

† On Milford haven.

The earlier bards knew of no tomb for Arthur, as this quotation suggests:

“ Bedwyr’s grave at Allt Tryvan  
 A grave for March and a grave for Guythur,  
 A grave for Gwgawn of the ruddy sword.  
 Not wise (the thought) a grave for Arthur.”<sup>(20)</sup>

The belief of the Welsh and, above all, the Bretons of Brittany in the undying Arthur was strengthened enormously by the renewed attacks on Celtic independence in the twelfth century. Of Brittany, for example, it was said concerning the undying Arthur—

“ That it was most true is proved to-day by the varying opinions of men on Arthur’s death and life. If you do not believe me, go to the realm of Armorica, which is lesser Britain, and preach about the market place and villages that Arthur the Briton is dead as other men, and the facts themselves will show you how true is Merlin’s prophecy, which says that the ending of Arthur shall be doubtful. Hardly will you escape unscathed, without being whelmed by the curses or crushed by the stones of your hearers.” Alain de Lille, *Prophetica Anglicana*.

Another example—the posthumous son of Geoffrey of Anjou was named thus in 1187. The entry reads curiously:

“ Natus est Arthurus, filius Gaufridi, desideratus gentibus.”

Arthur had in fact acquired a definite political value. His name was a rallying signal for the Welsh insurgents. Of them it was written concerning the belief current at the end of the twelfth century:

“ The King will return, in strength and power, to rule over the Britons as they think according to his word, wherefore they still await his coming, even as the Jews their Messiah, deceived by an even greater folly and unhappiness, and infidelity to boot. They are often deceived and labour in vain, for they do not know the appointed day.”

The existence of such a political menace in the legend of the undying Arthur called forth an ingenious and natural response from those faithful followers of the English Crown, the Monks of Glastonbury, who but a short time before had been rewarded for their help in the Crown’s dispute with St. Thomas of Canterbury. Abbot Henry (inspired, it is said, by a secret message from the Bards!) surrounded the area between two old Saxon pyramids in the monks’ graveyard with a curtain. He ordered the monks to dig, and found there the *grave* of Arthur. Giraldus Cambrensis records it thus:—

“ In our days the body of the King, which fables had made into something fantastic in its ending, as if it had been carried far away by spiritual agency, and was not liable to death, was found between the pyramids in the churchyard at Glastonbury and taken honourably in the church for decent burial in a marble tomb. It lay deep in the ground in a

hollowed oak and was marked with wonderful and as it seemed miraculous tokens. One of these was a leaden cross attached to a stone beneath the coffin with an inside inscription on its inner face toward the stone: 'Hic jacet sepultus inclitus rex Arthurus cum Wenneveria uxore sua secunda in insula Avallonis.' "

The remains were re-buried in the new abbey church and brought much prestige and many pilgrims to the Abbey. But even this did not straightway kill the story of the undying King. He continued to trouble the English Crown, and his name and rumours of his coming were sufficient to rouse the Welsh to rebellion a hundred years after his grave had been "discovered." What was reputed to be his crown was surrendered to Edward I at Carnarvon in 1282.

Though the undying Arthur opposed England in Wales, the dead Arthur was put forward as a valuable ally in the dispute with Scotland. In 1301, Edward I, on the slender and imaginative basis of Geoffrey of Monmouth's *Historia*, claimed dominion over Scotland, and actually appealed to Pope Boniface VIII on the ground that "Augustus held Scotland as a vassal of Arthur." For a time Scotland had no ready answer, but some eighty years later they found that the legend could be given a most ingenious twist. They stressed Arthur's alleged illegitimacy, claimed Mordred as the rightful heir and the Picts as allies of the Britons against the Saxons. Appropriately enough, 142 years later still, an Aberdonian, Hector Boece, in his *Scotorum Historia* published Scotland's fullest version of this new Arthurian legend, and thus became the fount of all Scottish Arthurian folk-lore. The real Arthur was never in Scotland.

Thus, by the fourteenth century, there were current the native Arthurian legends in Wales and Brittany and, of course, the former Kingdom of Dumnonia. These also had as variants borrowings from romance. England shared with France the romances and literature of the Arthurian cycle already quite changed in character since Geoffrey's *Historia*. Scotland had her own politically-inspired variants of the English legends. Similar processes have operated in all lands and at all times, and the results are a fertile source of confusion to those who seek history in legend.

A later expression of belief in an undying Arthur is contained in a reference to the final re-interment of Arthur at Glastonbury:

"At Glastonbury on the queere

They made Artourez tounbe here

And wrote with Latyn verses thus:

'Hic jacet Arthurus, rex quandum rexque futurus.' "(21)

Legendary heroes change their nationality readily. The two big Celtic groups in Britain and on the Continent each claim him as their own, though in all probability he never left Britain. In the fourteenth century he nearly became the Patron of England, for as Froissart tells us, Edward I, in 1344, planned an order of chivalry

and actually convened a great feast at Windsor to consider his proposed "Order of the Round Table."<sup>(22)</sup> Later this became "The Order of the Garter."

Let us now consider another great group of Arthurian legends which have much in common with similar legends in other lands. In fact, Arthur's name has in these merely displaced that of an earlier hero. Their strong culture-hero characteristics are obvious.

Arthur, resting from his labours and sleeping in some hollow cave or enchanted hill. This is a very common expression conveying the sense of the other world. With them I commence my final group of Arthurian stories, those in folk-lore.

There are many resting places of Arthur in Britain, but that need not surprise us, as most such heroes, like Queen Elizabeth, slept in many places. Arthur sleeps in—

- (1) Caerleon with all his court.
- (2) South Cadbury, Somerset, in a hollow hill with iron gates which open on St. John's Eve. He is there with his court and a pack of hounds.
- (3) At Craig-y-dinas in South Wales, in a cavern with treasure hoard guarded by a bell.
- (4) Beneath the castle ruins at Sewingshield, Northumberland, with his court, Guinevere and a pack of hounds.
- (5) Beneath Richmond Castle in Yorkshire.
- (6) At Bwlch y Saethan, where he fell in defending the pass, while his men rest nearby on Snowdon in a cavern deep in the hill. This story has reappeared in connection with a cavern newly found near Aberdare in Glamorgan (*Auckland Star*, June, 1938). The discoverer told the Press he was exploring for King Arthur and his knights and treasure.
- (7) Beneath Mount Etna in Sicily, which legend is at least as old as 1194 A.D., and was no doubt carried by the Norman followers of King Robert.
- (8) And many more besides.

From the romances we have the many versions of his sleeping to be healed of his wounds. They are but a literary expansion and fanciful elaboration of the older folk belief. One quotation suffices:

"Therefore Morganis, a noble matron who was ruler and patron of those parts and akin to King Arthur by blood, took him after the battle of Kemelen to the island which is now called Glastonbury for the healing of his wounds." (*De Principis Instructione*, Giraldus Cambrensis, 1193.)

In all these legends Arthur sleeps usually surrounded by his court, his knights and his treasure, though sometimes—as often he was in life—without his Queen. He is usually awaiting the performance of a ritual by the one who has stumbled upon his hiding place.

This will enable him to awake again. In every case, as with Percival in the Grail quest, some essential task is left undone, some question unasked, and the spell remains unbroken and the treasure hoard lies intact. A typical example from Northumberland. At Sewing-shield, near Hadrian's Wall, King Arthur sleeps in the Castle vault, with Guinevere, all his knights and a pack of hounds. On a table lies a bugle-horn, a garter and a stone sword. When someone blows the horn and cuts the garter with the stone sword, the whole court will awaken. One day, a farmer exploring the ruins, found his way by chance to the vault. He cut the garter with the stone sword, but forgot to blow the horn. Arthur awoke, but fell sleep again with the words:

"O woe betide the evil day  
On which this luckless wight was born,  
Who drew the sword, the garter cut,  
But never blew the bugle-horn."

These stories have a remarkable resemblance to the old myths of the sleeping Cronus, whom Plutarch records as sleeping in an island in Britain:

"Moreover, they said, there is an Island in which Cronus is imprisoned with Briareus keeping guard over him as he sleeps, for, as they put it, sleep is the band forged for Cronus and they add that around him are many divinities, his henchmen and attendants."

In all these fables the pack of hounds is present to remind us of the great hunting of Twrch Trwyth.

Perhaps the traditions at South Cadbury deserve further mention, as bearing on the myth of the sleeping Arthur. Cadbury is near Glastonbury. Leland and Camden identified the site as Camelot, and indeed named the camp "Camalat." In the sixteenth century, it was believed to be Arthur's camp, and the discovery of Roman coins, burials and a silver horseshoe were quoted as evidence in support. A nineteenth century rector carefully collected the local traditions:

"Folk do say that on the night of the full moon Arthur and his men ride round the hill and their horses are shod with silver, and a silver shoe has been found in the track where they do ride, and when they have ridden round the hill they stop to water their horses at the Wishing Well."<sup>(28)</sup>\*

The name of King Arthur has been locally preserved and attached to an almost forgotten bridle-path leading from the hill at Cadbury to Glastonbury. On the Eve of St. John or on a rough

---

\* In case so late a survival of legend-belief of this type arouses undue scepticism, I would point out that in 1939 A.D. the Rector of Cerne Abbas, Dorset, has found it necessary to protest against the practice of his spinster parishioners praying by moonlight to the Giant of Cerne—for the blessing of a husband or for success in love!

winter's night, the lonely labourer returning home may hear King Arthur and his hounds go by along the track. Folk-lore has preserved, perhaps by accident, the location of the old entrance to the Camp at Cadbury, now obliterated by ploughing and undiscernible even to an archaeologist, except by a line of ash trees growing in the now filled hollow-way. The Rector was half facetiously asking an old cottager where the iron gates of the Hollow Hill could be found, and was startled by the instant reply: "Why, doant ee know, zur, up among they ash trees."

The same processes that converted the earlier versions of Arthurian tales into their later romantic and extravagant form are even yet at work locally, for the Cadbury traditions have received poetic expansions as follows:

" . . . the village maiden treads,  
But knows that far beneath her feet within the *caverned* hill,  
King Arthur and his mail-clad knights are soundly sleeping  
still,  
With *golden* lamps reflected in polished marble floors,  
And ever watchful dragons guarding the *golden* doors,  
She knows that they who ne'er have sinned, nor caused a heart  
to grieve,  
Whose faith is pure and love is true, who kneel on St. John's  
Eve  
And lave their eyes in Arthur's Well, shall see the hill subside  
And passage open at their feet, the golden gates divide,  
And Arthur couched amid his knights, each girded with a  
sword,  
And by the tranced monarch's head, a priceless jewel hoard."

Arthur's name has sometimes slipped into a more ribald rhyme, as in Upper Hesket in Cumberland, where an itinerant and inn-frequenting antiquary heard this rhyme:

"When as King Arthur ruled this land,  
He ruled it like a swine,  
He bought three pecks of barley meal  
To make a pudden fine.

His pudden it was knodden well  
And stuffed right full of plums  
And lumps of suet he put in  
As big as my two thumbs."

But perhaps this is but an echo of the Scottish propaganda of Hector Boece.

Folk-lore, like folk memory, is very unreliable, and is always changing. In many parts of Cornwall there is a succession of legends attached to the same antiquities or site. Dozmary Pool, formerly associated with the devil-ridden Tregeagle, now has Arthurian associations. Against this can be set Bodrugan Head, which in the sixteenth century was associated with Sir Bors de Ganis. Now there

is also a story of a hero who took a spectacular leap from this headland. In the tenth century the hero was Tristan, now it is Henry de Bodrugan, who chose the wrong side at Bosworth Field.<sup>(24)</sup>

A hairdresser at Taunton said that the Wellington monument near Taunton was put up to commemorate the defeat of the Danes by King Arthur at the battle of Sedgemoor!\*

Such are the lapses of folk memory, than which none is more remarkable than that of the Glastonbury car-driver who pointed out to a distinguished fare the hut where *Arthur* burnt the cakes!

Many identifications of Arthurian sites are of very recent origin. For example, in 1839, a well at Walton Crag in Northumberland was said to be the one at which St. Paulinus baptised his converts. Now it is known as "Arthur's Well." At about the same period, a local writer noted the Cornish habit of ascribing almost every unknown antiquity to King Arthur. Motives, similar to those which prompted Abbot Henry to find Arthur's grave, exist to perpetuate or originate legends to-day. In one of the leading English railway companies' carriages can be seen photographs of some picturesque mediaeval ruins at Tintagel which have been found to post-date even Geoffrey of Monmouth. The ruins are described as "King Arthur's Castle, Tintagel." The journey to see them is one of the longest on the line!

A final miscellany of tales follows. King Arthur wanders in various guises. In Cornwall he is associated with the raven, sometimes with the Cornish cough. Cervantes said he wandered in the guise of a bird. In the thirteenth century *Dreams of Rhonabwy*, ravens play a prominent part in the gathering of the host at the Battle of Badon.<sup>(25)</sup> King Arthur often rides at night as at South Cadbury. He is also said to have founded Cambridge University, a counterblast to University College (Oxford's) claim to Alfred as a traditional founder. At Caerleon in 1799 he gave his name to a well-known inn, whose sign reads:—

" Though o'er my door, yet take my word  
To honour you he's able  
And make you welcome with good ale,  
And Knights of the Round Table."

This inn's sign perpetuated the earlier local belief that Arthur's Round Table, like his court, was at Caerleon, a belief no older than Geoffrey of Monmouth.

Mention of Geoffrey occasions my last reference to the literary Arthur. Of all the developments in the legend of Arthur none is more remarkable than the immediate and almost unquestioned acceptance of the wild imaginings of the *Historia*, within a few years of the authoritative dismissal of such fancies by William of Malmesbury. There were, however, a few not entirely disinterested contemporary sceptics. One amusing example will perhaps be forgiven.

---

\* This incident was communicated by Mr. O. G. S. Crawford, to whom I am also indebted for several suggestions and corrections since the paper was read.

It is again from Giraldus Cambrensis, in his *Itinerarium Kambriae* (1191), speaking of:

"Meilerius of Caerleon . . . who claimed the power of telling truth by the help of demoniac familiars. The devils were exorcised by placing the Gospel of St. John on his bosom. But when, by way of experiment, the Gospel was removed and Geoffrey Arthur's history of the Britons was put in its place, then all the devils came back thicker than before."

It would seem that the reduction of a legend to literary form, so far from fixing it, only leads to an intensification of changes. But is the converse true? Can the legend and genealogies transmitted for generations by the "tohunga" of Polynesia be regarded as having kept unchanged their earlier form? Are they any more reliable than the extensive folk-lore of Southern Scotland, purporting to show former activities of Arthur and much of which dates from the fourteenth century political uses of Arthurian legend; or that of Cornwall, which in many cases is no older than the *Idylls of the King*? How much reliance can be placed upon this orally transmitted material for the purpose of reconstructing an exact history of Polynesia? Surely these legends and genealogies can hardly have escaped the many influences which have moulded, formed and distorted the original Arthur until he seems to have lost all resemblance to his original self, location or nationality. To draw safe historical conclusions, legends must be studied in their earlier, as well as their later, forms. Their travel must be followed, and allowance made for the many factors and influences which worked to mould them.

Words applied to the Greek mythology over three hundred years ago still hold good for many legends to-day:

"Seeing they are diversely related by writers that lived near about one and the self-same time, we may easily perceive that they were common things, derived from precedent memorials and that they became various by reason of the diverse ornaments bestowed on them by particular relations."<sup>(26)</sup>

The greatest caution must be observed lest the later accretions be mistaken for the original essentials.

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THE LATE JAMES SCOTT MACLAURIN.

## OBITUARIES.

**James Scott Maclaurin (1864–1939).**

WITH the passing of Dr. J. S. Maclaurin, Dominion Analyst from 1901 to 1930, New Zealand has lost not only a responsible official with a long record of able service, but one of her outstanding scientific men.

Dr Maclaurin came to New Zealand in early boyhood with his parents, who settled in the Waikato. Educated first at a public school, then at Auckland Grammar School, he attended the Auckland University College, specialising in the study of Chemistry under Professor F. D. Brown. He graduated B.Sc. in 1891, gained first class Honours in 1892, and in 1897 was awarded the degree of Doctor of Science for outstanding research on the solution of gold in dilute solutions of potassium cyanide. This research aroused great interest in gold mining circles throughout the world, confirming as it did that oxygen was necessary for the solution of the gold, and was the basis of many subsequent improvements in the cyanide process for treatment of gold ores. It gained for him election to the Fellowship of the Chemical Society, of London. It also enabled him to qualify for an 1851 Exhibition Scholarship, but this he declined, and the way was thus opened for Ernest Rutherford, who took up the scholarship, to enter at Cambridge on the career which made him the most famous scientist of his day.

Dr. Maclaurin remained in Auckland as an analytical chemist in association with Mr. J. A. Pond, and in 1901 was appointed Colonial Analyst in Wellington, the title being changed to that of Dominion Analyst in 1909, when New Zealand was raised to Dominion status. At first he was associated only with the Mines and Public Health Departments, but gradually other Departments drew on his services, and he became in effect the chief chemical adviser to the Government. In 1909 he was appointed Chief Inspector of Explosives, and by introducing an effective system of testing and inspection re-organised the administration of the Explosives and Dangerous Goods Act. He was largely responsible for the form in which the Gas Regulations issued in 1924, were finally drafted, and as Chief Gas Examiner, controlled gas and meter testing throughout New Zealand. In all his activities he quickly gained the full confidence of his associates, and was equally successful in administrative and in purely scientific work.

Dr. Maclaurin's work for all Departments was invariably thorough. As a witness in police cases he was convincing and eminently fair, and throughout his long career his evidence in court was never shaken. Due to the confidence reposed in him by the Health Department and the acceptance of his recommendations regarding samples analysed under the Sale of Foods and Drugs Act, food adulteration was persistently checked, and has never reached serious proportions in New Zealand.

Few persons had a better acquaintance with the mineral resources of New Zealand than he. As analyst to the Geological Survey he had examined rocks and minerals from all districts, and though no outstanding discoveries resulted, a considerable fund of useful knowledge was built up. Iron ores from Parapara, also Taranaki, iron-sand were analysed fully, also the iron manufactured from them by companies at Onekaka and New Plymouth respectively. Petroleum oils from New Plymouth, Waitangi (Gisborne), Waiotapu, and Kotuku were all examined, also natural gas from many places. Shales from Orepuki, Waikaia, and Totara North were considered as possible alternative sources of oil. Extraction of mercury from ores at Puhi Puhi was investigated. Peat samples of a special series, collected throughout the Dominion, were analysed for a Royal Commission in 1913, and some work was undertaken later on the distillation of Kauri-swamp peat. Coal from every known occurrence in New Zealand was analysed, and briquetting of slack, also low temperature carbonisation of typical coals, investigated on a semi-commercial scale. Keen interest was taken in improvement of ventilation and other safety measures in mines.

Always alert for new methods, Dr. Maclaurin introduced the freezing point determination for detection of added water, and the reductase test into the routine of milk testing in the Dominion Laboratory long before they were in general use in similar laboratories elsewhere. New methods, however, were never accepted without rigorous trial.

In his later years Dr. Maclaurin devoted all the time that could be spared from other duties to research on Kauri gum and *Phormium tenax* (New Zealand flax). He developed solvents for kauri gum and for resin in buried kauri timber. He also patented a process for purification of fine swamp gum, based on differential flotation in a salt solution of definite density before and after the application of a vacuum. With phormium he investigated the economics of chemical bleaching and its effect on the strength of the fibre, also the production of fibre by an "explosion" process. He also did considerable laboratory work on the production of cellulose from phormium. It is to be regretted that none of this work on kauri gum or phormium was published.

Dr. Maclaurin was very conversant with the mineral waters of New Zealand, having carefully analysed practically all of them. Always observant for any unusual feature, he noted the presence and determined the amount of pentathionic acid in water from White Island, an acid not previously known to occur in nature. His work on the radio activity and radium content of gases, waters, and sinters of the thermal regions, for which he constructed most of the required apparatus, was outstanding in merit.

Most of Dr. Maclaurin's work fulfilled its purpose at the time, and is now buried in Departmental files. That carried out for the Geological Survey personally or under his direction can be found in the Survey publications. Analyses of general interest were

included in the Annual Reports of the Laboratory. Apart from these, Dr. Maclaurin's publications were:—

*Journal Chemical Society.*

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Briquetting of New Zealand Coals, 58th A.R., 1926.

Dr. Maclaurin was a Fellow of the Chemical Society, a Member of the Society of Chemical Industry, a Member of the Society of Public Analysts, all of Great Britain, and a Fellow of the Royal Society of New Zealand. Indifferent health precluded him from taking an active part in the meetings of local societies. One recalls, however, with deep feeling such personal qualities as accurate knowledge, insight, skill, kindness, courtesy, ready access, and willingness to help any who approached him.

One monument to his memory is the Dominion Laboratory organisation which he built up. Beginning with one cadet assistant, he leaves behind him a central laboratory in Wellington with three branches in other cities and a staff which includes thirty-two graduate chemists. More enduring still is the intangible stimulus that men of Dr. Maclaurin's high principle and achievement give to the enriching of national character and life.

W. D.

## Edward Kidson (1882-1939).

EDWARD KIDSON was born at Bilston, Staffordshire, on 12th March, 1882. The son of Mr. and Mrs. Charles Kidson, he belonged to a family well known in Nelson and Christchurch. Educated at Nelson College, he obtained an Entrance Scholarship and took his university course at Canterbury College. In 1906, he obtained a Senior Scholarship, and was awarded the degree of M.Sc. with first class honours in Physics. The following year he completed the honours course in Mathematics and obtained his M.A. degree.

In 1905 he was appointed Assistant at the Magnetic Observatory in Christchurch, and in 1908 he joined the staff of the Carnegie Institution of Washington. Till 1914 he worked on magnetic surveys in South America, Newfoundland, at sea, and in Australia. During his two years at sea on the research ship *Carnegie* he made the observations for the navigation of the vessel. In 1914 he was engaged on a magnetic survey in the interior of Australia and some time elapsed before the party heard that war had been declared. From 1915 till 1919 he served with the Meteorological Section of the Royal Engineers. With the rank of Captain, he commanded a section which developed the forecasting service and the application of meteorology to gunnery for the Salonica Expeditionary Force. For his successful work he was mentioned in despatches and awarded the O.B.E. (Military Division).

In 1919, he was appointed Observer-in-Charge of the Watheroo Magnetic Observatory in Western Australia, and in 1921 he became Supervising Meteorologist and Assistant Director of the Commonwealth Meteorological Service. He was a member of the Australian National Research Council. In 1924 he was elected a Fellow of the Institute of Physics, and in the same year was awarded the degree of D.Sc. (N.Z. University) for a thesis embodying the results of a research on cloud heights carried out in Melbourne. In 1927, he was appointed Director of the Meteorological Service in New Zealand.

In 1931, Dr. Kidson was elected a Fellow of the New Zealand Institute, now the Royal Society of New Zealand. He was one of the comparatively small band of those who regularly attended meetings of the Wellington Philosophical Society, and was one of the Society's representatives on the Council of the Royal Society of New Zealand from 1932 to 1936.

When Dr. Kidson assumed control of the New Zealand Meteorological Office, he set himself the task of building up a scientific service in this country. He foresaw the coming development of aviation and the important part which New Zealand would play in trans-ocean air services, and he strived to anticipate the ever-increasing demands for meteorological information which have arisen. When he took charge he had a staff of four. At the time of his death there were forty. In order to lay the foundations of a sound aviation meteorological organisation in this area, he convened, in 1937, a very successful conference for the Southwest Pacific. At this conference



THE LATE EDWARD KIDSON.



he was elected President. Though he did not live to see the inauguration of regular trans-Tasman and trans-Pacific flights, Dr. Kidson was instrumental, from the meteorological side, in making such services possible.

At international conferences in Europe and elsewhere, and at other scientific conferences, especially those in Australia and New Zealand, papers which he presented were always regarded as most valuable contributions to the advancement of the science of Meteorology. He published numerous original papers with particular reference to forecasting and the use of observations of the upper atmosphere, and specialised in the meteorology of the Antarctic regions, on which he was a world authority.

Dr. Kidson's energy and application to his subject were remarkable. Almost every evening he would spend two or three hours either reading current meteorological journals—he could read French, German, and Spanish—or in pursuing some research, generally in connection with Antarctic Meteorology.

He was specially selected to write a critical study of the meteorological records of the first Shackleton Antarctic Expedition (1907-09), and, at the time of his death, had just completed a similar discussion of those of Sir Douglas Mawson's Australasian Antarctic Expedition of 1911-14. This latter work occupied the greater part of his spare time during the last eight or nine years and includes daily weather charts for the Antarctic quadrant to the south of Australia and New Zealand, analysed for the first time according to modern "frontal" methods. This work will be published shortly in Australia and will itself form a fitting memorial to the outstanding contribution which its author made to the knowledge of meteorology in Australasia.

Dr. Kidson stood in the front rank of British Meteorologists and had earned for himself an international reputation. In 1931 he was elected to the International Meteorological Committee, and always took an active interest in all the work of the International Meteorological Organisation. He attended the Conference of Empire Meteorologists held in London in 1935, and then took part in the International Conference of Directors of Meteorological Services which met that year in Warsaw. In both 1931 and 1935 he visited Norway, and returned to New Zealand with a first-hand acquaintance of modern frontal methods of analysing weather charts.

Although pre-eminent in the field of meteorology, Dr Kidson had a wide knowledge of other branches of physical science. He was also a good administrator. As a consequence of his modest and unassuming character it was only those who had the privilege of close association with him who learned to appreciate fully the value of his advice and the soundness of his judgment no matter what the subject might be. His criticism was always constructive, and to the point.

News of his sudden and unexpected death on 12th June, 1939, came as a profound shock to his friends and colleagues in all parts of the world.

In the passing of Edward Kidson, New Zealand has lost a public servant and a man of science of the highest standing. M. A. F. B..

## The Variation of Gravity Within the Earth.

By K. E. BULLEN, *Auckland University College.*

[Read before Auckland Institute, February 15, 1939; received by the Editor, February 1, 1939; issued separately, September, 1939.]

IN two recent papers, Benfield (1937) and Olczak (1938) have given figures for the attraction due to gravity at various points in the interior of the earth, the calculations being based on the writer's solution (1936) of the variation of density within the earth.

As in the latter paper, let  $\rho$  be the density at a point P distant  $r$  from the earth's centre, and  $M$  the mass enclosed by a concentric sphere through P. Let  $\alpha$ ,  $\beta$  be the velocities of  $P$  and  $S$  seismic waves at P, and  $\gamma$  the constant of gravitation. Then in the course of the writer's solution of the density problem, the following equation had been set up:—

$$\frac{d\rho}{dr} = -\gamma Mr^{-2}\rho/(\alpha^2 - \frac{4}{3}\beta^2),$$

and had been applied successively to give the rate of density alteration at each point taken in the earth's interior. The right-hand side contains the factor  $\gamma Mr^{-2}$  which had been determined explicitly on each occasion; and this expression of course gives directly the gravitational attraction at distance  $r$  from the earth's centre.

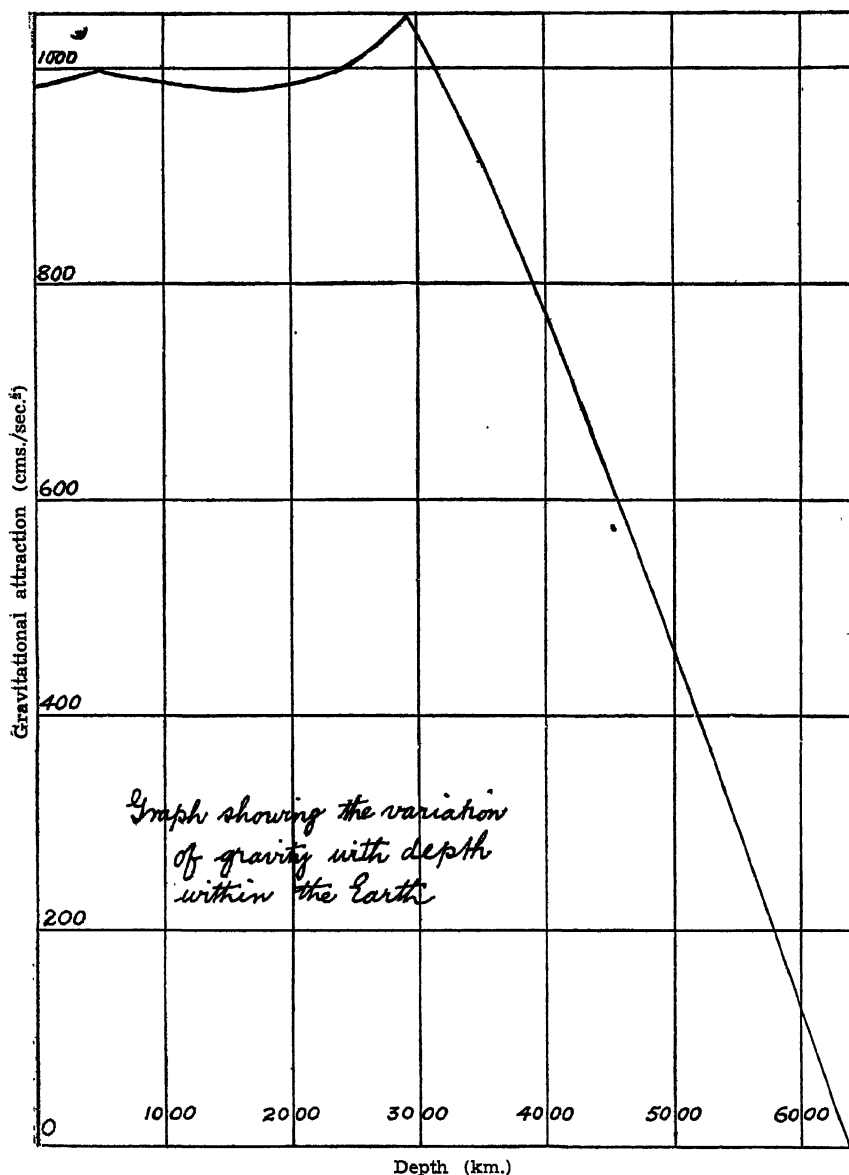
The results of Benfield and Olczak were obtained by using the final published density figures of the writer, and accordingly involved a fair amount of additional computation. It may therefore be of interest to give the actual values of the function  $\gamma Mr^{-2}$  as found directly by the writer, such values being subject to the minimum of computation errors.

The values to be given are based on the auxiliary material prepared during the writer's revised solution (1937) of the density variation. Allowance has further been made for the improved estimate of the earth's mass at  $5.976 \times 10^{27}$  gms., as given by Olczak. In this connection it is of interest to point out that the same figure for the earth's mass was independently given recently by Jeffreys (1937). A corresponding approximate adjustment for this was made by Benfield and Olczak, but more accurate allowance is possible using the auxiliary figures of the writer's earlier papers.

The values thus obtained by the writer for the gravitational attraction  $g$  cms./sec.<sup>2</sup> at various depths  $d$  km. below the earth's surface are as follows—

$d$	$g$	$d$	$g$	$d$	$g$
0	982	2000	985	4200	714
100	986	2200	990	4400	654
200	989	2400	1000	4600	592
300	992	2600	1014	4800	528
400	995	2800	1034	5000	463
474	997	2920	1048	5200	398
600	995	3000	1031	5400	331
800	991	3200	986	5600	264

$d$	$g$	$d$	$g$	$d$	$g$
1000	988	3400	936	5800	196
1200	985	3600	885	6000	127
1400	982	3800	831	6200	59
1600	981	4000	774	6371	0
1800	982				



The general variation of  $g$  is exhibited in the accompanying diagram, and is similar to the results of Benfield and Olczak, although the values are for the most part a little higher. This is due partly

to the use of the writer's revised solution (1937) for the density variation, and partly to the more accurate adjustment corresponding to the increased mass adopted for the earth; the effect of the latter is to increase the density more at the greater depths than near the earth's surface. The discontinuities of gradient at depths of 474 and 2920 km. are associated with maxima of 997 and 1048 cms./sec<sup>2</sup> respectively. The minimum value of  $g$  in the earth's outer shell is about 981 cms./sec.<sup>2</sup>, and occurs at a depth of about 1620 km. Inside the central core gravity diminishes to zero by a nearly linear law.

The adoption of an increased mass affects slightly the density figures given by the writer (1937) for the central core. These now range from 9.77 at the boundary to 12.29 at the earth's centre. Above the central core there is virtually no alteration necessary.

A few further remarks are necessary concerning the solution given. First, it is not yet certain from the seismological evidence exactly how sharp is the new discontinuity placed at 474 km. depth. If the transition is fairly gradual, the effect will be essentially to smooth out the discontinuity in the gradient of the gravity curve at this depth, but other features of the curve will be preserved. Any modification made will be fairly small, since, as pointed out by the writer (1938) there are a number of independent lines of evidence which all support the occurrence of a change in composition in the earth at a depth of order 500 km.

Secondly, Gutenberg and Richter (1938) have recently made the suggestion that the central core itself may be composite with possibly two changes of material inside. This is liable to affect slightly the variation of gravity within the central core, but the general solution for the whole earth should not be greatly disturbed; since the mass of the central core is less than a third of the mass of the earth.

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## A Review of the Tertiary and Recent Neozelanic Pyramidellid Molluscs. No. 6—The Genus *Odostomia*.

By C. R. LAWS, D.Sc., Auckland.

[Read before the Auckland Institute, November 18, 1938; received by the Editor, November 29, 1938; issued separately, September, 1939.]

### THE ODOSTOMID GROUP OF GENERA.

THE Odostomid group of genera comprises those with few whorls, a not greatly elevated spire, a single columella-fold, and a typically depressed embryo. The sculpture varies from shells devoid of all ornamentation to those with either axial ribs or spirals, or with both.

The Odostomid group of genera can be divided into three sub-groups, as follows:—

*Odostomia* and allied generic groups (Odostomids).

*Pyrgulina* and allied generic groups (Pyrgulinids).

*Evalea* and related genera.

### ODOSTOMIDS.

This division embraces Pyramidellids of only moderately high conic habit, few whorls, and a single columella-fold. The embryo is usually considerably immersed, and not as exsert as that of *Turbonilla* or *Syrnola*. Axial sculpture other than growth-lines is not present; and strong, regular, universal spiral ornamentation is not a feature of the group, though fine microscopic striae or threads may be present. If spiral sculpture stronger than microscopic striae or threads is developed, it takes the form of an incised line bordering the suture, or, as in the case of *Scalenostoma*, *Cyclodostomia*, and *Doliella*, of one or two tumid bands or keels.

New Zealand species fall under seven genera, of which three are new. The present paper deals only with the genus *Odostomia*, which is divided into two groups:—

(1) Nucleus evident, helicoid . . . . . *Odostomia* A.

(2) Nucleus not projecting . . . . . *Odostomia* B.

A key to the genera, also tables of stratigraphic range of genera and species will be given in a later number.

The earliest Odostomid in the New Zealand area is "*Odostomia* sp." (known from a single specimen) recorded by Finlay and Marwick from beds of late Cretaceous age at Boulder Hill, Dunedin (*N.Z. Geol. Surv. Pal. Bull.*, no. 15, p. 66, pl. 5, fig. 6, 1937). In Otataran beds three species of *Odostomia* A are represented, none of which is strong in individuals, however. Thereafter, in the Hutchinsonian (Upper Oligocene) five species occur, but, with the exception of *O. obstinata* n.sp., which is a strong species and which persisted into the Miocene, the Hutchinsonian forms are represented by very few individuals. The Miocene records a decline in the number of species, and since Miocene (Awamoan) beds are the most richly fossiliferous in New Zealand, and yield a large number of species and individuals, this is rather to be wondered at. It is

more especially remarkable in contrast with the fossil Turbonillids, which attained their maximum importance at this time. Seven species are found in the Pliocene, but none of these have persisted from Miocene times, though five of them appear also in the Recent fauna. Four species are confined to the Recent.

### Genus ODOSTOMIA Fleming.

1817. Fleming, *Edinburgh Encycl.*, vol. 7, pt. 1, p. 76.

Type (*vide* Dall and Bartsch): *Turbo plicatus* Montagu.

*Odostomia* in the strict sense has the following characters:—Spire not greatly elevated, few whorls, and a single columella-fold. The surface is typically smooth. Strong, universal spiral sculpture is absent. Fine microscopic spiral striae may, or may not, be present. Any spiral sculpture stronger than microscopic striae, if present, is confined to an incised line bordering the suture. The protoconch is low, considerably immersed, and thus contrasts with that of Turbonillids and Syrnolids. Cossmann (*Ess. de Paléoconch. Comparée*, p. 235, 1921) states that the protoconch is small and obtuse. His figure of the genotype shows (*loc. cit.*, Planche-Texte A, fig. 81) the nucleus to be polygyrate and apparently helicoid.

Two groups based on the embryo can be distinguished. Group A of this paper comprises *Odostomia* with projecting lateral nucleus. Into Group B fall species whose lateral nucleus is not evident. Owing to the considerably immersed protoconch of *Odostomia* it has not been possible always to determine confidently the character of its coiling, for in cases where there is a little extra tilting or immersion the nucleus may be almost entirely hidden below the suture of the first normally coiled whorl.

### *Odostomia* Group A.

#### KEY TO SPECIES OF *Odostomia* A.

Whorls quite flat or nearly so.

Periphery distinctly angled.

Shell of moderate size, not less than 4.0 mm.

Spiral sculpture entirely absent; suture indistinct, not at all cut in; outlines perfectly straight; growth-lines vertical. . . . .

*obstinata*

Traces of indistinct spirals on last whorl; suture more cut in; outlines a little pupoid above. . . . .

*vixornata*

Shell small, less than 4.0 mm.

Shell heavy, stoutish; peripheral angulation not sharp; growth-lines oblique. . . . .

*chattonensis*

Shell of lighter build, not stout, but more elevated; peripheral angulation very well marked.

Shell slender; whorls quite flat, overhanging suture. . . . .

*mahoenuica*

Shell not quite so slender; whorls lightly concave, swollen below suture and at periphery of last whorl. . . . .

*awatumida*

Periphery not distinctly angled.

Shell 5.5 mm. high or over; outlines straight.

Shell moderately tall and slender, suture margined below; periphery quite evenly rounded. . . . .

*waipaoa*

Shell not so slender, but body-whorl distinctly wider; suture not margined below, but an incised spiral line on periphery; periphery sub-angled. . . . .

*bartrumi*

Shell considerably less than 5.5 mm. high; outlines pupoid.

Spire gradate; periphery low, sub-angled; spirals lacking. . . . . *ancisa*

Spire not gradate; periphery higher, not sub-angled.

Suture margined on both sides by incised spiral lines. . . . . *pervaga*

Suture not margined, shell minute. . . . . *geoffreyi*

Whorls convex, not flat.

Shell 3.0 mm. tall or over.

Whorls only lightly convex.

Fine microscopic striae present.

A single incised spiral line present bordering suture behind and on periphery of last whorl.

Spiral cords absent.

Shell large, of heavy build; whorls more bulging over lower third and much broader than high; body-whorl less than half height of shell. . . . . *pudica*

Spiral cords present.

Irregular, low spiral cords present; shell rather stout. . . . . *chordata*

Two incised spiral lines present, one bordering each side of suture.

Shell fairly large, of heavy build; outlines straight; columella almost straight. . . . . *zeccorpulenta*

Fine microscopic striae absent.

Outlines straight to lightly convex; height of body-whorl less than half that of shell; embryo large and heavy; shell narrowly umbilicate. . . . . *vaga*

Whorls strongly convex; sutures well impressed.

Shell stout; body-whorl capacious, its height half that of shell; umbilicate; no spirals present. . . . . *takapunaensis*

Shell not stout; body-whorl less in height than half that of shell; not umbilicate; a single incised spiral line above suture. . . . . *incidata*

Shell less than 3.0 mm. high.

Spire gradate; sutures much impressed.

Whorls flatly convex; shell thick and heavy for its size; an incised spiral line above suture. . . . . *sheriffi*

Spire not gradate; suture not strongly impressed.

Aperture rhomboidal; whorls a little overhanging; columella-fold inconspicuous. . . . . *waitakiensis*

Aperture sub-ovate.

Columella-fold pronounced giving a strong twist to columella and placed below insertion. . . . . *ototarana*

Columella-fold small, not unduly pronounced, situated at insertion; two incised spirals, one bordering each side of suture. . . . . *turneri*

Note.—*O. arowhana* (Marwick) is not included in the key, as the unique holotype has been lost, and no specimen has been available for study.

### ***Odostomia obstinata* n.sp. (Fig. 11.)**

Shell small, conic; spire elevated, about  $2\frac{1}{2}$  times height of aperture, its outlines straight. Post-nuclear whorls  $6\frac{1}{2}$  in number, quite flat, the sharply angulated periphery closely overhanging suture. Protoconch small, heterostrophic, coiled in a helicoid spiral of about two volutions, the nucleus rather less than one-half immersed.

Axial sculpture absent; spiral sculpture represented by the peripheral angulation only. Body-whorl short, flat above, its periphery strongly angled and bearing a low spiral cord; base short, lightly convex, rapidly retreating to axis of shell; aperture quadrate, angled behind, broadly rounded in front, the outer lip somewhat effuse, especially below; columella thick, set vertically, arcuate, a moderately strong, horizontal plait near its insertion; inner lip with a thin, narrow band of callus; outer lip straight.

Height, 4.4 mm.; width, 2.0 mm. (holotype).

Localities: Shell-bed, Target Gully, Oamaru (type); Pukeuri, Oamaru; Rifle Butts, Oamaru; Ardgowan, near Oamaru; Chatton, near Gore; Clifden, Southland, new road-cutting behind racecourse (= band 7 of the beds along the river), also bands 6A, 8A. All are Awamoan horizons with the exception of band 6A, Clifden, which is Hutchinsonian; and Chatton (Ototaran).

Type in Auckland Museum (ex writer's collection).

***Odostomia vixornata* (Marwick). (Fig. 2.)**

1931. *Syrnola vixornata* Marwick, *N.Z. Geol. Surv. Pal. Bull.*, no. 13, p. 105, fig. 198.

This has not the long tapering habit of typical *Syrnola*, and is better located in *Odostomia*. The single specimen has its surface too poorly preserved to permit any definite pronouncement concerning the nature of its sculpture, though on the body-whorl there are indications of several widely spaced incised spiral lines. The pillar-plait looks very strong and probably influenced Dr. Marwick, but the aperture is broken. The protoconch, which is heterostrophic and of helicoid coiling, is depressed as in *Odostomia* and not exsert as in *Syrnola*. The flattened whorls and general habit are reminiscent of *O. waipaoa* (Marwick), also from Gisborne District.

Height, 4.8 mm.; width, 1.8 mm.

Locality: N.Z.G.S. loc. 1237, Gisborne District, Ihungia Series (Hutchinsonian).

Type (unique) in collection of N.Z. Geological Survey, Wellington.

*O. bartrumi* n.sp. is a similar shell, but has a blunter apex, less sharpened summit to spire, and possesses a single incised spiral line close above suture.

***Odostomia chattonensis* n.sp. (Fig. 20.)**

Shell very small, conic, of heavy build; spire just over twice height of aperture, its outlines straight to faintly convex. Post-nuclear whorls  $5\frac{1}{2}$  in number, quite flat, and angled at periphery; suture only a little impressed. Protoconch heavy for size of shell, heterostrophic, coiled in a helicoid spiral of about two volutions, its nucleus large and one-half immersed. Axial sculpture absent; spiral sculpture of excessively fine microscopic striae. Body-whorl short, flat above, its periphery sub-angled; base short, lightly convex, rapidly drawn in to axis of shell; apertural features as for *O. obstinata*, but plait not so prominent; outer lip broken away.

Height, 3.0 mm.; width, 1.3 mm. (holotype).

Locality: Chatton, near Gore, Southland (Ototaran).

Type in Auckland Museum (ex writer's collection).

This species differs from *O. obstinata*, its nearest ally, in its constantly smaller size, heavier embryo, and in its possession of spiral striae. Also, the growth-lines are antecurrent to posterior suture and not vertical as in *obstinata*.

**Odostomia mahoenuica** n.sp. (Fig. 15.)

This species is undoubtedly of the same lineage as *O. obstinata*, from which it is distinguished by its smaller size, more attenuate habit, and heavier and larger embryo with strongly bulging nucleus. The plait is rather weaker, and the whorls, which are quite flat, are more sharply angled above suture, which they overhang more than do those of *obstinata*.

Height, 3.0 mm.; width, 1.0 mm.

Locality: Mahoenui beds, Awakino River, about one mile east of north entrance to Awakino Gorge (Hutchinsonian); Blue Cliffs.

Type in writer's collection

**Odostomia awatumida** n.sp. (Fig. 13.)

This species also is a close relative of *O. obstinata* and its allies. It is distinguished by small size, light build, excessively fine microscopic striae (seen only on good specimens), light plait, and a low sub-sutural swelling frequently causing whorls to appear faintly concave. The suture is but little impressed. The margined suture separates *awatumida* from related species; the whorls are not overhanging, though the angulation is quite distinct.

Height, 2.7 mm.; width, 1.0 mm. (holotype).

Localities: White Rock River (type); Sutherlands, South Canterbury. Both are Awamoan horizons.

Type in Auckland Museum (ex writer's collection).

subsp. **convexa** nov.

Certain shells from White Rock River, Sutherlands, Holme Station, and Opihi River (all Awamoan horizons near Timaru, South Canterbury) have the spire lightly convex in outline, the subsutural swelling more pronounced, and the whorls somewhat staged. This form is not considered distinct enough from the species to warrant more than varietal separation from it.

**Odostomia waipaoa** (Marwick). (Fig. 9.)

1931. *Syrnola waipaoa* Marwick, N.Z. Geol. Surv. Pal. Bull., no. 13, p. 105, fig. 200.

1931. *Syrnola lutosa* Marwick, N.Z. Geol. Surv. Pal. Bull., no. 13, p. 100, figs. 194, 199.

This species is of high conic habit, but is not sufficiently slender for *Syrnola*, and is accordingly removed to *Odostomia*. The sunken heterostrophic protoconch is of helicoid coiling, the nucleus about one-half immersed, and Odostomid, not Syrnolid. Fine microscopic striae are not developed, but two incised spiral lines are present, one as a margin below posterior suture, the other just above anterior suture. This is typical of many other New Zealand *Odostomia*, and not of *Syrnola*.

*Syrnola lutosa* Marwick and the present species are undoubtedly conspecific, and *lutosa* must give place to *waipaoa*, which has page preference. Marwick, in comparing these two forms, distinguishes

the former from *waipaoa* by its sub-angled periphery of body-whorl and by the absence of a bordering spiral thread below the suture. The type is the only specimen of *lutosa*, and, though the surface is finely corroded, there is one portion well enough preserved to show two incised spiral lines as in *waipaoa*. Further, as *lutosa* is hardly adult, the sub-angulation of the body-whorl is expectable, for in immature specimens of *Odostomia* the same character is frequently present, and it is usually only the fully adult shells that possess the regularly convex periphery of the body-whorl. Immature specimens of *waipaoa* have the same sub-angulation.

Height, 5.9 mm.; width, 2.0 mm. (holotype).

Locality: N.Z.G.S. loc. 1236, Gisborne District, Ihungia Series (Hutchinsonian).

Type and a number of paratypes in collection of N.Z. Geological Survey, Wellington.

***Odostomia bartrumi* n.sp. (Fig. 1.)**

Shell of moderate size, elongate-conic; height of spire nearly twice that of body-whorl, its outlines straight. Post-nuclear whorls  $6\frac{1}{2}$  in number, flat to very faintly convex; suture incised. Protoconch heterostrophic, of about two volutions, coiled in a low helicoid spiral; nucleus small, its lower edge tangent to suture of first adult whorl. Excessively fine microscopic spiral striae absent; there is one incised spiral line close above suture, and indication of one or two obsolete, raised spirals near summit of last whorl. Body-whorl of moderate height, flat above, roundly sub-angled at periphery, base convex and full; aperture sub-ovate, angled behind, not widely rounded in front; columella thin, set vertically, arcuate, its plait conspicuous, horizontal and situated just below insertion; outer lip thin, straight.

Height, 5.1 mm.; width, 2.0 mm. (holotype).

Locality: Kaawa Creek beds (Waitotaran).

Type and many paratypes in writer's collection.

Separated from related forms by its high spire and flat outlines. This shell is listed and figured as *Odostomia* sp. by Bartrum and Powell in their paper on the Kaawa Creek mollusca (*Trans N.Z. Inst.*, vol. 59, p. 161, pl. 28, fig. 32, 1928). Several fine specimens have recently been collected.

Named in honour of its discoverer, Professor J. A. Bartrum, of the University College, Auckland.

***Odostomia ancisa* (Marwick). (Fig. 19.)**

1931. *Syrnola ancisa* Marwick, *N.Z. Geol. Surv. Pal. Bull.*, no. 13, p. 106, fig. 196.

This species is not of sufficiently tall habit to warrant its location in *Syrnola*, and it is here regarded as an undoubted *Odostomid*. The spire has convex outlines. The surface of the shell is badly preserved, so that spiral ornamentation may have been present. The apex is a typical *Odostomid* sunken one, not exsert as in *Syrnola*.

Height, 3.2 mm.; width, 1.4 mm.

Locality: N.Z.G.S. loc. 1340, Gisborne District, Ihungia Series (Hutchinsonian).

Type (unique) in collection of N.Z. Geological Survey, Wellington.

**Odostomia pervaga** n.sp. (Fig. 14.)

Shell very small, conic; height of spire about half that of shell, its outlines convex. Post-nuclear whorls  $4\frac{1}{2}$  in number, earlier ones lightly convex, later ones nearly flat; suture impressed. Protoconch small, sharpened at summit; heterostrophic, coiled in a helicoid spiral; nucleus about one-third immersed. Spiral sculpture consists of two incised lines close to suture, one posterior to it and the other anterior. Length of body-whorl about half that of shell, its outline flat above, sharply convex at periphery, broadly convex on base, which is fairly long; aperture sub-ovate, angled behind, not widely rounded in front; columella set vertically, arcuate, its plait heavy, strongly entering aperture, and situated not far below parieto-columella junction, which is obtusely angled; outer lip partially broken back, but apparently straight.

Height, 2.8 mm.; width 1.2 mm. (holotype).

Localities: Takapuna Beach, Auckland, in shell sand (type); Oneroa, Waiheke Island; Orua Bay, Manukau Harbour; junction of Ruakopatuna and Makara Streams, South Wairarapa (Pliocene).

Type in Auckland Museum (ex writer's collection).

The flat whorls, convex outline, and heavy plait set below insertion of columella make this species distinctive.

**Odostomia geoffreyi** n.sp.

Shell minute, height of spire rather less than that of body-whorl, its outlines straight. Post-nuclear whorls nearly four in number, very lightly convex to flat; suture distinct. Protoconch heterostrophic, the lateral nucleus considerably immersed and not prominently projecting. Faint microscopic spiral striae present on most whorls; incised spiral lines absent. Body-whorl slightly over half height of shell, its periphery strongly convex; base flattish; aperture pyriform; columella arcuate, set vertically, a small but distinct plait at insertion.

Height, 1.85 mm.; width, 0.85 mm. (holotype).

Locality: Auckland Harbour (type); Onetangi, Waiheke Island.

Type in writer's collection.

This is the smallest of our Recent *Odostomia*. A figure of this species will be given in the next part of this series of papers.

**Odostomia pudica** Suter. (Fig. 3.)

1908. *Odostomia pudica* Suter, *Trans. N.Z. Inst.*, vol. 40, p. 366, pl. 29, fig. 14.

1913. *Odostomia pudica* Suter, *Man. N.Z. Moll.*, p. 340, pl. 17, fig. 1 (Atlas).

Suter's description of shape of whorl is hardly satisfactory. It cannot strictly be regarded as "flat," for the lower half is somewhat swollen and more bulging than the zone above; it is drawn in moderately rapidly to anterior suture and cut in closely and horizontally to posterior one. A little posterior to suture and almost on the greatest bulge of whorl there is one incised spiral line, which is continued around periphery of last whorl, and this no doubt gave

Suter the impression of an "angle" on the whorls, which, however, is not strictly correct. Fine microscopic striae can here and there be picked up. The type specimen is a beach shell, rather worn, and it is probable that the striae, originally universal, have been obliterated. The protoconch is heterostrophic, helicoid (low), and very considerably immersed, so that only an extremely narrow zone of nucleus appears.

Height, 5.2 mm.; width, 2.2 mm. (holotype).

Localities: Bay of Islands (type); Takapuna, Auckland.

Type in Wanganui Museum.

The type is the only undoubted specimen the writer has seen. Suter (*Manual*, p. 340) has compared his species with *O. hyphala* Watson, from 700 fathoms north-east of East Cape (Challenger Station 169). The type of Watson's species, however, is lodged in the British Museum, so that no comparison can be made by the present writer.\*

Here again Suter's figure is at fault, quite useless, and entirely misleading. In his description the whorls are described as "flat"; but his illustration shows them very strongly convex with deeply cut in sutures, and is not at all reminiscent of the actual specimen.

#### ***Odostomia chordata* Suter. (Fig. 10.)**

1907. *Odostomia (Evalea) chordata* Suter, *Trans. N.Z. Inst.*, vol. 40, p. 348, pl. 27, fig. 5.

1913. *Odostomia (Evalea) chordata* Suter, *Man. N.Z. Moll.*, p. 342, pl. 17, fig. 5 (Atlas).

A glance at this shell is sufficient to raise one's doubts as to its correct location in *Evalea*. The sculpture of narrow cords separating the wider unsculptured areas is certainly not that of the group to which Suter referred the species. Two characters point unmistakably to its affinity with *Odostomia*. First, there is an incised spiral line forming a margin posterior to the suture, and this, as already seen, is a feature very common amongst certain Neozelanic species of *Odostomia*. Second, the embryo is a quite typical Odostomid one; the summit of the shell has not the *Evalea* "look," and the lateral nucleus is apparent, a little over one-half immersed, and coiled in a low helicoid spiral.

The spiral cords are weak, irregularly spaced, and obsolete in parts, and it is doubtful whether additional material would show them to be a constant feature of the species.

Height, 3.6 mm.; width, 1.8 mm. (holotype).

Locality: Five miles south of Cuvier Island, in 38 fathoms; Hen and Chickens Islands, in 25 fathoms; Petane (Nukumaruan).

Type in Wanganui Museum.

\* Watson's figure and description show that his species can be distinguished from *pudica* by absence of spiral lines, and by flexuous growth-lines, very slight plait, and shorter base. The outline of whorl is very similar in both species.

**Odostomia zecorpulenta** n.sp. (Fig. 7.)

Shell rather large, narrowly umbilicate, conic, elevated; height of spire one and one-third times that of body-whorl, its outlines straight. Post-nuclear whorls 6 in number, faintly convex; suture well impressed. Protoconch small, tilted, coiled in a low helicoid spiral; nucleus about one-half immersed. Spiral sculpture of obscure microscopic striae, seen here and there on good specimens only; suture faintly margined below by an incised spiral line, and above by a much stronger incised spiral; several low, widely spaced, almost obsolete spirals traverse centre part of whorl. Body-whorl remarkably distended and strongly convex from suture down over base (in immature shells only is the periphery sub-angled); aperture very broadly ovate; columella set vertically, arcuate, its plait small and situated not far below insertion; parietal wall thinly callused; outer lip straight.

Height, 5.3 mm.; width, 2.2 mm. (holotype).

Localities: Petane, Hawke's Bay, Pliocene (Nukumaruan), type; junction of Ruakokopatuna and Makara Streams, South Wairarapa (Pliocene); Kereru and Devil's Elbow (Nukumaruan).

Type in writer's collection.

**Odostomia vaga** n.sp. (Fig. 18.)

Shell small, narrowly umbilicate, conic; spire moderately elevated, twice height of aperture, its outlines straight. Post-nuclear whorls  $4\frac{1}{2}$  in number, convex; suture well impressed. Protoconch large, conspicuous, of heavy build, heterostrophic, coiled in a high helicoid spiral, the nuclear portion very strongly projecting, almost overhanging succeeding volution; nucleus small, practically free of immersion. Spiral sculpture absent. Height of body-whorl less than half that of shell; body-whorl convex above and on base, periphery angulated; aperture ovate, well opened out; columella set vertically, arcuate, a light but definite plait just below its insertion; inner lip callused; outer lip thin, straight.

Height, 3.6 mm.; width, 1.8 mm. (holotype).

Localities: Off Oamaru, in 50 fathoms (type); off Otago Heads, in 40 to 50 fathoms; Hen and Chickens Islands, in 25 fathoms; Snarres Islands, in 50 fathoms; Petane, Hawke's Bay, Pliocene (Nukumaruan); Te Piki, Cape Runaway (Castlediffian).

Type in Auckland Museum (ex Finlay collection).

The character of embryo, angulated periphery, and presence of umbilical perforation serve to distinguish this species, which must be a very hardy one, as shown by its extended Recent distribution and its range in time.

**Odostomia takapunaensis** Suter. (Fig. 5.)

1908. *Odostomia takapunaensis* Suter, *Trans. N.Z. Inst.*, vol. 40, p. 365, pl. 28, fig. 10.

1913. *Odostomia takapunaensis* Suter, *Man. N.Z. Moll.*, p. 341, pl. 17, fig. 2 (Atlas).

Suter's description of this species as "narrowly umbilicate" is not precise, at least so far as it relates to adult shells, for the type of his species and many topotypes are rather widely perforated for

*Odostomia*. The shell is short and stout, and consists of about five post-nuclear whorls. The figure in the *Atlas* is of little use. It shows the whorls much too convex, and omits the sub-angulation at periphery of body-whorl, which itself is not shown sufficiently wide in relation to height. The protoconch is greatly submerged as a whole, and is in a low helicoid spiral, the small lateral nucleus about one-half emergent. There is no spiral sculpture.

Height, 3.65 mm.; width, 2.0 mm. (holotype).

Locality: Takapuna reef, Auckland, in sand (type); Oneroa, Waiheke.

Type in Wanganui Museum. A number of topotypes from Takapuna Beach and from 3-4 fathoms off Takapuna in writer's collection.

***Odostomia incidata* Suter. (Fig. 8.)**

1908. *Odostomia incidata* Suter, *Trans. N.Z. Inst.*, vol. 40, p. 348, pl. 27, fig. 6.

1913. *Odostomia incidata* Suter, *Man. N.Z. Moll.*, p. 338, pl. 16, fig. 21 (Atlas).

This species is reminiscent of *O. pudica* Suter, which also is a tall form of somewhat similar build. Further similarity lies in the possession by both species of a single incised spiral line above sutures. *Pudica*, however, has a sub-angled periphery, which is absent in the present species. Suter's figure of *incidata* shows the whorls too convex. The protoconch is in a low helicoid spiral, the nucleus rather more than one-half immersed.

Suter's paratype is an encrusted shell, and doubtfully referable to this species.

Height, 4.3 mm.; width, 1.6 mm. (holotype).

Localities: Five miles south of Cuvier Island, in 38 fathoms (type); Hen and Chickens Islands, in 25 fathoms.

Type in Wanganui Museum.

The shells from Hen and Chickens Islands in particular are rather stouter than the type, but in other respects possess all the characters of the species. Possibly this divergence in habit is to be explained by abnormality in the growth of the holotype itself, for a serious fracture crosses one of the mid-spire whorls.

***Odostomia sherrii* Hutton. (Fig. 17.)**

1883. *Odostomia sherrii* Hutton, *Trans. N.Z. Inst.*, vol. 15, p. 411.

1893. *Odostomia sherrii* Hutton, *Macleay Mem. Vol. Plioc. Moll.*, p. 58.

1900. *Actaeon minutissima* Murdoch, *Trans. N.Z. Inst.*, vol. 32, p. 216, pl. 20, fig. 5.

1915. *Odostomia (Jordaniella) sherrii* Hutton. Suter, *N.Z. Geol. Surv. Pal. Bull.*, no. 3, p. 16, pl. 8, fig. 17.

Suter's reference to *Jordaniella* cannot be upheld. A very narrow, microscopic, incised spiral line traverses most whorls not far above suture. In no sense can this be regarded as a sulcus, so that the name *Jordaniella* must be dropped. Though *incidata*, *acutangula*, and *pudica* are likewise characterised by the presence of a fine peripheral spiral groove, Suter did not locate them in *Jordaniella*, but in *Odostomia* s.str.

The protoconch is heterostrophic, in a low helicoid spiral, the nucleus about one-half immersed.

Suter's drawing in the *Palaeontological Bulletin* gives a fair representation of the general form of the shell, but it makes his so-called "sulcus" much too prominent a feature. Striae are entirely absent.

Height, 2.4 mm.; width, 1.0 mm. (holotype).

Localities: Wanganui, Pliocene (type); Big King Island, in 100 fathoms; Petane (Nukumaruan).

Type in Canterbury Museum, Christchurch.

The topotypes have not so prominent a shoulder on the whorls; otherwise they match the type well. Some of the shells from Big King Island show faint indication of a subsutural incised spiral line.

***Odostomia waitakiensis* n.sp. (Fig. 4.)**

Shell very small (probably not quite adult), conic, of heavy build for its size; height of spire  $1\frac{1}{2}$  times that of aperture, its outlines straight. Post-nuclear volutions  $3\frac{1}{2}$  in number, very lightly convex, sub-angled at periphery and a little overhanging; suture not very distinct. Protoconch heavy, heterostrophic, coiled in a helicoid spiral, its nucleus large and very little immersed. Spiral sculpture absent. Body-whorl half height of shell, very lightly convex to flattish above, periphery sub-angled; base fairly long and lightly convex; aperture quadrate, angled behind, fairly widely rounded in front; columella thick, set vertically, a little arcuate, the plait indicated by a light swelling at its insertion; outer lip straight.

Height, 1.8 mm.; width, 0.9 mm. (holotype).

Locality: Otiake (Waitakian).

Type in Auckland Museum (ex Finlay collection).

The light convexity of whorl, long body-whorl, and lack of spiral sculpture separate this species from *O. chattonensis*. From *O. obstinata* it is distinguished by smaller size, heavier build, convexity of whorl, and long body. The lightly convex whorl also separates it from *mahoenuica*.

***Odostomia ototarana* n.sp. (Fig. 6.)**

Shell very small, conic; height of spire a little less than that of body-whorl, its outlines straight. Post-nuclear whorls 3 in number, lightly convex; suture impressed. Protoconch large and heavy for size of shell, heterostrophic, coiled in a high helicoid spiral; nucleus markedly projecting and overhanging first adult volution. Spiral sculpture of excessively fine microscopic striae (seen on paratype). Height of body-whorl greater than half that of shell; body-whorl flatly convex above, convex to sub-angled at periphery, base flattish, slightly concave towards columella; aperture sub-ovate, angled behind, not widely rounded in front; columella set vertically, arcuate, with a strong twisted fold spirally entering aperture; inner lip not callused; outer lip thin, straight.

Height, 1.7 mm.; width, 0.9 mm. (holotype).

Locality: Chatton, near Gore, Southland (Ototaran).

Type in writer's collection.

The heavy embryo of high helicoid coiling and strong twisted plait are characteristic.

*Odostomia turneri* n.sp. (Fig. 16.)

Shell very small, conic; height of spire  $1\frac{1}{2}$  times that of aperture, its outlines straight. Post-nuclear whorls 4 in number, lightly convex; suture not much impressed. Protoconch heterostrophic, coiled in a low helicoid spiral, nucleus considerably immersed. Fine microscopic spiral striae absent; spiral sculpture represented by two incised lines, one margining posterior suture, the other close above anterior suture and on periphery of whorl. Height of body-whorl slightly over half that of shell, its outlines convex over periphery and base, flattish above; aperture sub-ovate, widely rounded in front, angled behind; columella thick, set vertically, arcuate, its plait horizontal and situated near insertion; inner lip shows no callus; outer lip thin, straight.

Height, 2.5 mm.; width, 1.2 mm. (holotype).

Locality: Castlecliff, Wanganui (Castlecliffian), type; Manukau Harbour (Recent); Devil's Elbow, Napier-Wairoa Road (Nukumarian); Kaawa Creek (Waitotaran); Hawera (Waitotaran).

Type in Auckland Museum (ex writer's collection).

Named in honour of Dr. F. J. Turner, Department of Geology, Otago University.

*Incertae sedis.*

*Odostomia arowhana* (Marwick). (Fig. 12.)

1931. *Syrnola arowhana* Marwick, *N.Z. Geol. Surv. Pal. Bull.*, no. 13, p. 106, fig. 197.

The unique holotype has been lost, so that it has not been possible to examine the embryonic characters of this species. In the meantime, then, until further specimens are available, the species is not definitely located. According to Marwick the sculpture is similar to that of *O. vizornata*, which is located in *Odostomia* Group A, but if the apex proves to be of planispiral type, it will have to be referred to *Odostomia* Group B.

*Arowhana* is not sufficiently attenuate for *Syrnola*, where Marwick originally placed it.

Height, 4.5 mm.; width, 1.8 mm.

Locality: Tutamoe Series, N.Z.G.S. loc. 1298 (Awamoan), Gisborne District.

The illustration is a reproduction of Dr. Marwick's figure.

*Odostomia* Group B.

Group B has all the characters of Group A save that the nucleus is not evident projecting laterally. In species in which the protoconch is not greatly depressed it is seen to be paucispiral and planorboid; but in others the considerably sunken embryo makes it impossible to observe the lateral nucleus, so that the character of embryonic

coiling cannot be definitely established; for, as pointed out earlier in this paper, where there is a little extra tilting or immersion of the embryo, the nucleus may become entirely hidden below the suture of the first normally coiled whorl.

KEY TO SPECIES OF *Odostomia* B.

Shell 3.5 mm. in height or over.

Whorls flat or nearly so, overhanging suture, angulated; plait small but distinct.

Periphery distinctly angled; outlines straight; whorls quite flat. . . . . *castlecliffensis*

Periphery sub-angled; outline rather pupoid towards summit; whorls very lightly convex; peripheral thread present. . . . . *haurakiensis*

Whorls convex, not flat; plait not distinct.

Whorls strongly convex, roundly shouldered, spire gradate. . . . . *murdochi*

Whorls not strongly convex, little or not shouldered; spire not gradate.

Height of aperture less than one-third that of shell.

Whorls moderately convex, little shouldered; no spiral sculpture whatever; protoconch considerably exsert. . . . . *vestalis*

Height of aperture greater than one-third that of shell.

Whorls lightly convex; not shouldered.

Microscopic striae present; one incised spiral line below suture. . . . . *pedica*

Microscopic striae absent; two incised spiral lines bordering each side of suture. *aucklandica*

Shell less than 3.5 mm. high.

Microscopic spiral striae present.

Incised spiral sculpture absent.

Columella with a strong twisted plait; whorls very flatly convex; suture not much impressed; periphery sub-angled. . . . . *gorensis*

Columella-fold weak or almost obsolete.

Suture moderately impressed.

Height of aperture nearly one-third that of shell, which is well elevated.

Body-whorl high; no angulation; aperture narrowly ovate. . . . . *cryptodon*

Body-whorl wide, sub-angled at periphery; aperture broadly and roundly ovate.

Peripheral cord present. . . . . *acutangula*

Peripheral cord absent. . . . . *parvacutangula*

Height of aperture nearly half that of shell, which is distinctly squat. . . . . *taumakiensis*

Suture strongly impressed; whorls flatly rounded; body-whorl angulated at periphery, with a weaker angulation just below. . . . . *biangulata*

Incised spiral sculpture present.

Two incised spiral lines bordering each side of suture; shell not stout; whorls flatly convex; protoconch not depressed but erect. . . . . *manukauensis*

Microscopic spiral striae absent.

Incised spiral sculpture absent; shell very small with a strong twisted plait and heavy embryo. . . . . *graviapicalis*

***Odostomia castlecliffensis* n.sp. (Fig. 21.)**

Shell of moderate size, high conic; height of spire  $2\frac{1}{2}$  times that of aperture, outlines straight. Post-nuclear whorls  $5\frac{1}{2}$  in number, flat, the periphery, which is low down near suture, distinctly angled and bearing a low spiral thread; suture strongly incised. Protoconch heterostrophic, planispiral; nucleus almost wholly immersed. Spiral sculpture confined to the weak thread on periphery. Body-whorl in height a little less than half that of entire shell, flat above, strongly angled on periphery, convex on base; aperture rhomboidal; columella set vertically, arcuate, its plait very weak and inconspicuous and situated at insertion. There is the very slightest indication of a narrow, almost linear umbilical chink; inner lip narrowly callused; outer lip straight, but angulated at periphery of whorl.

Height, 4.1 mm.; width, 2.0 mm. (holotype).

Locality: Castlecliff, Wanganui (Castlecliffian).

Type in Auckland Museum (ex writer's collection).

This species simulates *O. obstinata*, common in Awamoan beds at North Otago localities, but the divergent apical characters provide a ready means of separation.

***Odostomia haurakiensis* n.sp. (Fig. 24.)**

Shell small, narrowly umbilicate, high conic; height of spire  $2\frac{1}{2}$  times that of aperture, outlines pupoid. Post-nuclear whorls  $5\frac{1}{2}$  in number, convex, overhanging; the low periphery distinctly angled; suture deeply incised. Protoconch heterostrophic, planispiral, low; nucleus almost completely immersed. Spiral sculpture confined to a fine thread on angulated periphery. Body-whorl in height a little less than half that of shell, flatly convex above and on base, sub-angled at periphery; aperture broken, but probably originally rhomboidal; columella set vertically, arcuate, its plait moderately conspicuous and situated almost at insertion; inner lip narrowly callused; outer lip broken.

Height, 3.9 mm.; width, 1.7 mm. (holotype).

Locality: Hauraki Gulf, in 28 fathoms.

Type (unique) in Auckland Museum (ex Finlay collection).

The present species is a very close relative of *O. castlecliffensis*, and they both possess the same general style of shell. A ready means of separation is to be had, however, in the rather pupoid outline, heavier plait, more open umbilicus and more convex whorl of *haurakiensis*.

***Odostomia murchisoni* Suter. (Fig. 32.)**

1904. *Odostomia proxima* Murdoch, *Trans. N.Z. Inst.*, vol. 37, p. 220, pl. 8, fig. 19; not of de Folin, 1872.

1913. *Odostomia murchisoni* Suter, *Man. N.Z. Moll.*, p. 340, pl. 16, fig. 24 (Atlas).

The type material of this species consists of four shells, no particular one of which was designated as holotype by either Murdoch or Suter. None of the specimens agrees exactly with the dimensions given by Murdoch and copied by Suter, so that the writer now selects as lectotype the shell which most nearly approaches the

recorded dimensions. Suter's figure in the Atlas is a reproduction of Murdoch's drawing, and does not do justice to any one of the four shells. It makes the habit rather less stout than is typical, and does not portray the true shape of whorl. The outline of whorl is not evenly convex, as shown in Murdoch's illustration, but is flatly convex over centre and drawn in rather rapidly to sutures, especially to the posterior one, where there is almost a tabulation, so that the spire appears somewhat staged.

The protoconch is heterostrophic, apparently planispiral, the nucleus almost completely hidden in succeeding whorl.

Height, 4.0 mm.; width, 1.8 mm. (lectotype).

Localities: Whangaroa Harbour (type); Banks Peninsula, recorded by Iredale, *vide* Suter, Manual; but in the light of other distributions shown by the present paper this may be questioned.

Type in Dominion Museum, Wellington.

***Odostomia vestalis* Murdoch. (Fig. 33.)**

1905. *Odostomia vestalis* Murdoch, *Trans. N.Z. Inst.*, vol. 37, p. 227, pl. 8, fig. 20.

1913. *Odostomia vestalis* Murdoch. Suter, *Man. N.Z. Moll.*, p. 342, pl. 17, fig. 4 (Atlas).

The figure in the Atlas shows the whorls too flat and not sufficiently shouldered. The protoconch is more exsert than is usual for *Odostomia*, and is large, rather globose and planispiral. The general build and features of body-whorl and aperture remind one of *Gumina*, but the spire is much too high and the apex different.

Height, 4.4 mm.; width, 1.5 mm. (holotype).

Locality: Whangaroa Harbour.

Type in Dominion Museum, Wellington.

***Odostomia pedica* n.sp. (Fig. 34.)**

Shell small, high conic; height of spire about  $1\frac{1}{2}$  times that of aperture, outlines straight. Post-nuclear whorls  $4\frac{1}{2}$  in number, convex; suture impressed. Protoconch heterostrophic, planispiral; nucleus about one-half immersed. Fine microscopic striae present here and there on all whorls; one incised spiral line margins suture below. Body-whorl in height slightly over half that of shell, broadly convex in one sweep from suture to base; aperture subovate, angled behind, fairly widely rounded in front; columella set vertically, arcuate, its plait not visible externally, but seen as a low fold within aperture; inner lip narrowly callused; outer lip thin, straight.

Height, 3.8 mm.; width, 1.6 mm.

Locality: Snares Islands.

Type (unique) in Wanganui Museum.

This species has been separated from among Suter's paratypes of *O. inornata*, which has an apex of helicoid type, and from which it is also distinct in having the suture margined.

***Odostomia aucklandica* n.sp. (Fig. 28.)**

Shell of moderate size, conic, moderately elevated; height of spire twice that of aperture, outlines straight. Post-nuclear whorls

4½ in number, convex, closely shouldered above; suture well impressed. Protoconch heterostrophic, apparently planispiral, low; nucleus almost completely immersed. Fine microscopic spirals present; two fine incised spiral lines present bordering both anterior and posterior sutures; spiral sculpture seen only on good specimens. Body-whorl in height a little greater than half height of shell, its outline convex throughout in one broad sweep from suture to base; aperture broadly ovate, angled behind, effuse in front; columella about vertical, arcuate, its fold exceedingly weak, almost obsolete; inner lip distinctly narrowly callused; outer lip thin, straight.

Height, 4.1 mm.; width, 1.95 mm. (holotype).

Locality: Faith Harbour, Auckland Islands.

Type in Auckland Museum (ex Finlay collection).

*O. aucklandica* combines the characters of both *O. cryptodon* and *O. murdochi*. It resembles the former in possession of a weak plait and in apertural shape, and the latter it simulates very closely in general build of whorl and character of suture. The Faith Harbour shells, however, show some variability in the depth of incision of suture, and not all have the suture so deeply impressed and the shoulder so strong as *murdochi*. *Cryptodon* is a much smaller species with suture less incised and the body-whorl higher, and it lacks incised spiral lines.

***Odostomia gorenensis* n.sp. (Fig. 26.)**

Shell very small, conic; height of spire 1½ times that of aperture, its outlines straight. Post-nuclear whorls 3¼ in number, very lightly convex; suture not strongly impressed. Protoconch large for size of shell, rounded over summit, planorboid. Sculpture consists of excessively fine, rather wavy, microscopic spiral striae. Body-whorl in height equal to half that of shell, flatly convex above, sub-angled at periphery, convex on base; aperture rhomboidal, angled behind, moderately widely rounded in front; columella thick, a little oblique, arcuate, its plait conspicuous, blunt and situated some distance below insertion; inner lip not callused; outer lip straight.

Height, 2.2 mm.; width, 1.1 mm.

Locality: Chatton, near Gore, Southland (Ototaran).

Type (unique) in writer's collection.

***Odostomia cryptodon* Suter. (Fig. 29.)**

1908. *Odostomia cryptodon* Suter, *Trans. N.Z. Inst.*, vol. 40, p. 365, pl. 29, fig. 12.

1913. *Odostomia cryptodon* Suter, *Man. N.Z. Moll.*, p. 335, pl. 16, fig. 16 (Atlas).

Suter gives a very fair illustration of this species, but he shows the pillar insufficiently excavated and the body-whorl contracted to base too low down and too sharply. The planispiral apex is considerably immersed.

Height, 2.7 mm.; width, 1.5 mm. (holotype). Corresponding dimensions of shell from Dunedin Harbour: 4.0 mm.; 1.9 mm.

Localities: Te Onepoto Bay, near Lyttelton (type); Dunedin Harbour, under stones between tide marks; Moeraki; Taieri Beach; Chatham Islands (a worn shell); off Otago Heads, in 40 fathoms.

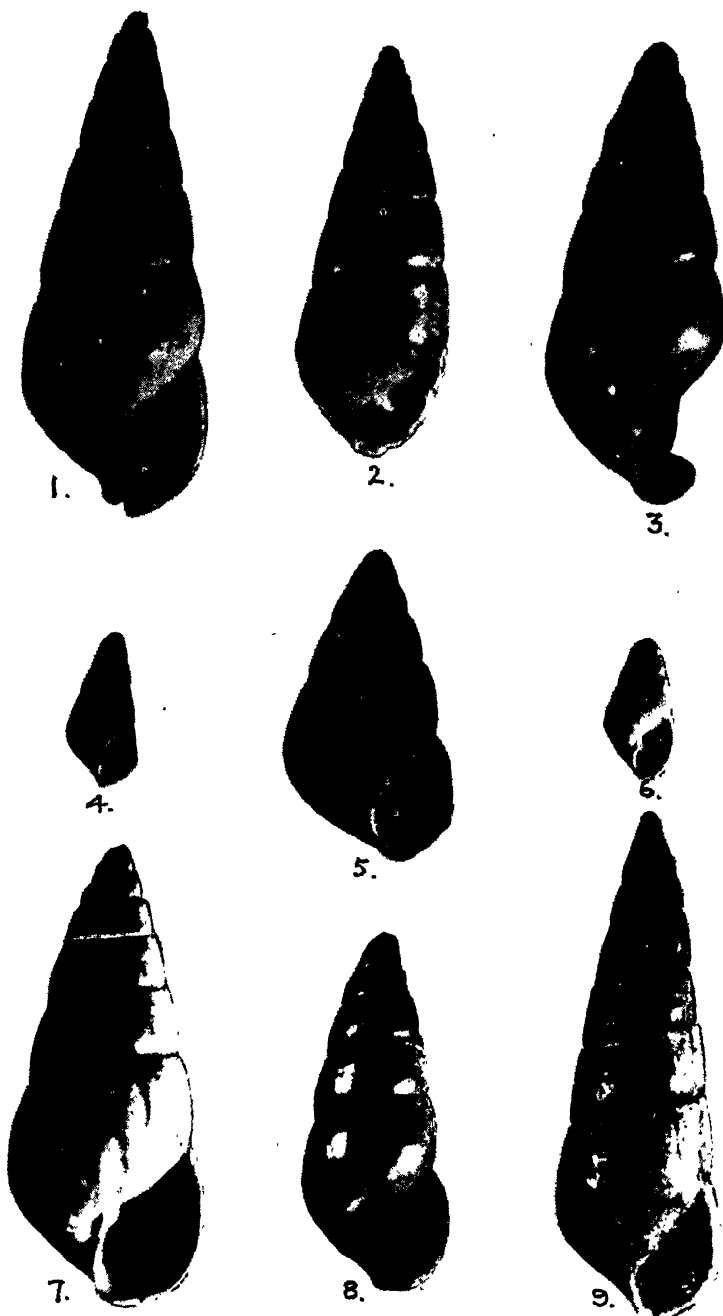


FIG. 1.—*Odostomia bartrum* n.sp.; paratype,  $\times 13$ . FIG. 2.—*Odostomia virornata* (Marwick); holotype,  $\times 13$ . FIG. 3.—*Odostomia pudica* Suter; holotype,  $\times 13$ . FIG. 4.—*Odostomia icatikiensis* n.sp.; holotype,  $\times 13$ . FIG. 5.—*Odostomia takapunaensis* Suter; holotype,  $\times 13$ . FIG. 6.—*Odostomia ototaruna* n.sp.; holotype,  $\times 13$ . FIG. 7.—*Odostomia zecorpulenta* n.sp.; holotype,  $\times 13$ . FIG. 8.—*Odostomia incidata* Suter; holotype,  $\times 13$ . FIG. 9.—*Odostomia icatipa* (Marwick); holotype,  $\times 13$ .



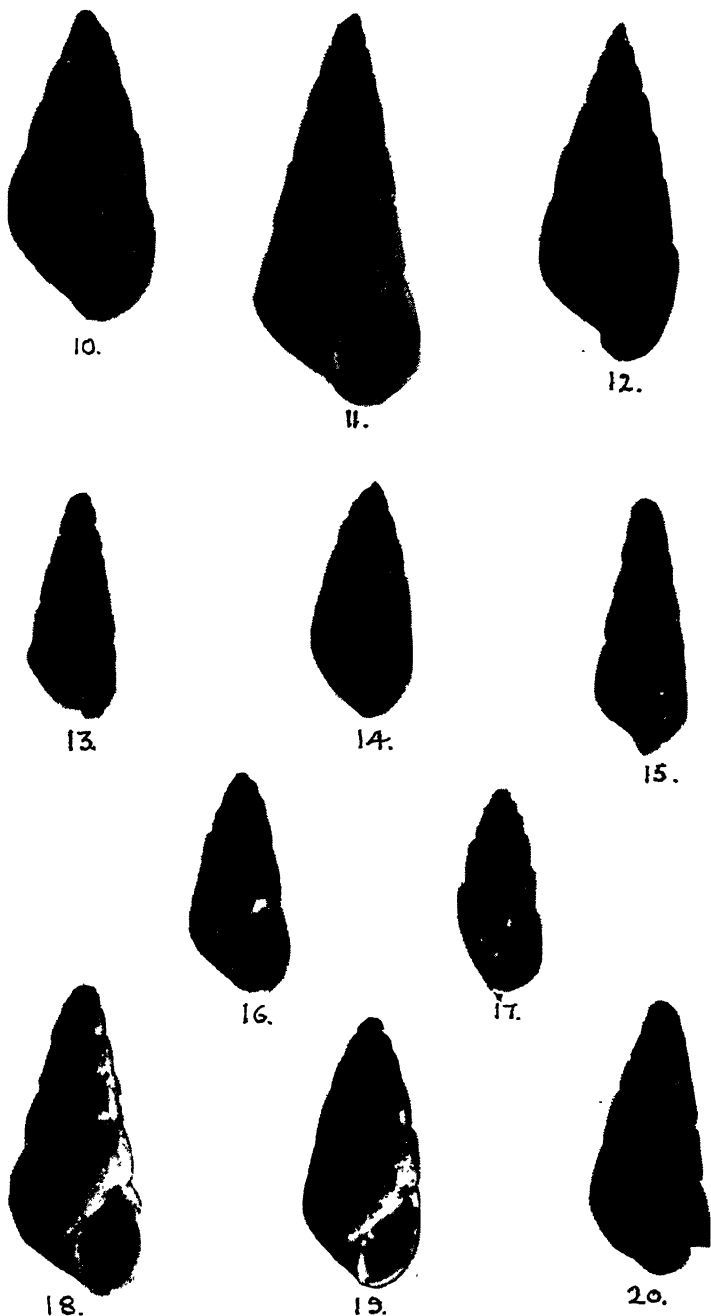


FIG. 10.—*Odostomia chordata* Suter; holotype,  $\times 13$ . FIG. 11.—*Odostomia obstinata* n.sp.; holotype,  $\times 13$ . FIG. 12.—*Odostomia arochana* (Marwick); holotype,  $\times 13$ . FIG. 13.—*Odostomia acatunida* n.sp.; holotype,  $\times 13$ . FIG. 14.—*Odostomia pervaga* n.sp.; holotype,  $\times 13$ . FIG. 15.—*Odostomia mahoenuica* n.sp.; holotype,  $\times 13$ . FIG. 16.—*Odostomia turneri* n.sp.; holotype,  $\times 13$ . FIG. 17.—*Odostomia sherriffi* Hutton; holotype,  $\times 13$ . FIG. 18.—*Odostomia raga* n.sp.; holotype,  $\times 13$ . FIG. 19.—*Odostomia ancisa* (Marwick); holotype,  $\times 13$ . FIG. 20.—*Odostomia chiltonensis* n.sp.; holotype,  $\times 13$ .



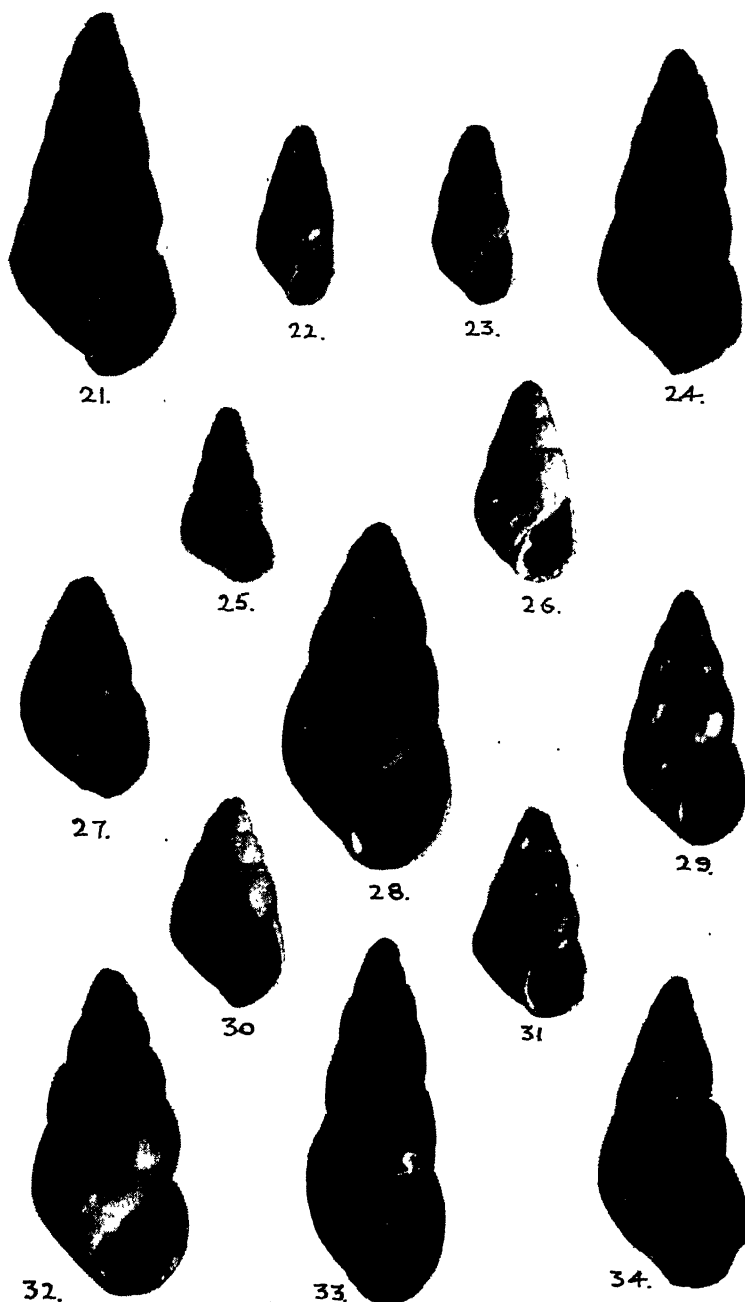


FIG. 21.—*Odostomia castleckiffensis* n.sp.; holotype,  $\times 13$ . FIG. 22.—*Odostomia grariapicalis* n.sp.; holotype,  $\times 13$ . FIG. 23.—*Odostomia biangulata* n.sp.; holotype,  $\times 13$ . FIG. 24.—*Odostomia haurakiensis* n.sp.; holotype,  $\times 13$ . FIG. 25.—*Odostomia parracutangula* n.sp.; holotype,  $\times 13$ . FIG. 26.—*Odostomia gomensis* n.sp.; holotype,  $\times 13$ . FIG. 27.—*Odostomia taumakiensis* Suter; holotype,  $\times 13$ . FIG. 28.—*Odostomia aneklandica* n.sp.; holotype,  $\times 13$ . FIG. 29.—*Odostomia cryptodon* Suter; holotype,  $\times 13$ . FIG. 30.—*Odostomia manukauensis* n.sp.; holotype,  $\times 13$ . FIG. 31.—*Odostomia acutangula* Suter; holotype,  $\times 13$ . FIG. 32.—*Odostomia murchisoni* Suter; holotype,  $\times 13$ . FIG. 33.—*Odostomia vestalis* Murdoch; holotype,  $\times 13$ . FIG. 34.—*Odostomia pedica* n.sp.; holotype,  $\times 13$ .





Type in Wanganui Museum.

The Dunedin Harbour shells provide a very perfect match of the type, which is an immature specimen, the surface of which is not well preserved, so that Suter was led to record the absence of spiral sculpture for this species. The shells from Dunedin Harbour, however, have irregularly spaced, wavy microscopic striae.

**Odostomia acutangula** Suter. (Fig. 31.)

1908. *Odostomia acutangula* Suter, *Trans. N.Z. Inst.*, vol. 40, p. 366, pl. 29, fig. 13.

1913. *Odostomia acutangula* Suter, *Man. N.Z. Moll.*, p. 334, pl. 16, fig. 14 (Atlas).

*Acutangula* is known from a single specimen. The periphery is angled and the angulation carries a low spiral cord. The figure in the Atlas gives a fair representation of the whorls of the spire, but it shows the body-whorl hardly enough distended, the angulation too sharp, the columella straight instead of arcuate, and the aperture too narrow and not broadly enough rounded in front.

The protoconch is heterostrophic and apparently planorboid, of about one volution, and well tilted. Most of the nucleus is submerged.

Height, 2.4 mm.; width, 1.2 mm.

Locality: Port Pegasus, Stewart Island, in 18 fathoms.

Type in Wanganui Museum.

**Odostomia parvacutangula** n.sp. (Fig. 25.)

Shell very small, conic, moderately elevated; height of spire  $1\frac{1}{2}$  times that of aperture, outlines straight. Post-nuclear whorls  $3\frac{1}{4}$  in number, lightly and evenly convex; suture impressed. Protoconch heterostrophic, planispiral, large, bulbous, exsert; nucleus about two-thirds immersed. Spiral sculpture not definite, traces of fine microscopic striae here and there. Body-whorl in height equal to about half that of shell, lightly convex above, flattish on base, periphery roundly angulated; aperture broadly oval, angled behind, effuse in front; columella thin, set vertically, arcuate, plait practically absent and indicated only by a broad, low swelling at insertion; inner lip thinly and narrowly callused; outer lip thin, straight; basal lip very broadly convex.

Height, 2.0 mm.; width, 1.0 mm. (holotype).

Locality: Auckland Islands, in 95 fathoms.

Type in Auckland Museum (ex Finlay collection).

These Auckland Island shells are in build, shell-form, and apical characters very close to *acutangula*, from Stewart Island, but they are smaller and have less convex whorls and almost obsolete pillar-plait.

**Odostomia taumakiensis** Suter. (Fig. 27.)

1908. *Odostomia taumakiensis* Suter, *Trans. N.Z. Inst.*, vol. 40, p. 363, pl. 28, fig. 7.

1913. *Odostomia taumakiensis* Suter, *Man. N.Z. Moll.*, p. 341, pl. 17, fig. 3 (Atlas).

Suter's figure in the Atlas shows the whorls too convex; they should be moderately and evenly rounded. His comparison with *O. murdochi* is faulty in part. The salient separative features he

does not comment on, viz., larger size and stouter habit of *murdochi*, which also has sutures much more strongly cut in and the spire somewhat stepped. The type of *murdochi* is imperforate, so that his comparison in reference to this character is of little value.

The protoconch is considerably immersed.

Height, 3.0 mm.; width, 1.5 mm. (holotype).

Localities: Taumaki Island, west coast of South Island, in 10 fathoms (type); Petane (Nukumaruan).

Type in Wanganui Museum.

***Odostomia biangulata* n.sp. (Fig. 23.)**

Shell very small, conic; height of spire a little over twice that of aperture, outlines straight. Post-nuclear whorls  $3\frac{1}{2}$  in number, lightly convex, shouldered above, cut in rapidly close to suture below; suture strongly incised. Protoconch heterostrophic, apparently planispiral, large, bulbous; nucleus considerably immersed (partly broken). Fine, microscopic striae over whole surface of last whorl and on base; a spiral angulation on periphery of body-whorl, and another, not so strong, on base not far below peripheral one. Body-whorl in height about equal to half that of shell, shouldered at summit, flatly convex above the sub-angled periphery, convex on base; aperture sub-ovate, angled behind, rather effuse in front; columella about vertical, arcuate, its plait small, high up and seen only within aperture; inner lip as a narrow callus; outer lip straight.

Height, 2.0 mm.; width, 0.9 mm. (holotype).

Locality: Shell-bed, Target Gully, Oamaru (Awamoan).

Type in Auckland Museum (ex writer's collection).

The biangulate character of the last whorl is a good means of separation.

***Odostomia manukauensis* n.sp. (Fig. 30.)**

Shell small, conic; height of spire  $1\frac{1}{2}$  times that of aperture, outlines straight. Post-nuclear whorls  $4\frac{1}{2}$  in number, increasing rather rapidly in size, very lightly convex; suture distinct. Protoconch heterostrophic, low, rounded, apparently planispiral; nucleus almost completely immersed. Ill-defined microscopic spirals over surface of later whorls; in addition there are two strongly incised spiral lines situated respectively close to anterior and posterior margins of whorl. Body-whorl capacious, lightly convex above and on base, somewhat sharply convex at periphery; aperture broadly subovate; columella set vertically, arcuate, a small, low swelling near its insertion; inner lip thinly and narrowly callused; outer lip effuse, thin, straight; basal lip drawn down and inwards towards axis of shell.

Height, 2.3 mm.; width, 1.3 mm. (holotype).

Locality: Orua Bay, Manukau Harbour (specimens from the collection of the Rev. W. H. Webster).

Type and several paratypes in War Memorial Museum, Auckland.

***Odostomia graviapicalis* n.sp. (Fig. 22.)**

Shell very small, conic; height of spire nearly twice that of aperture, its outlines straight. Post-nuclear whorls 4 in number, lightly convex; suture moderately impressed. Protoconch large, rather bulbous, planispiral; nucleus large, not central, a little immersed. Spiral sculpture entirely absent. Body-whorl in height equal to half that of shell, flatly convex above, sub-angled at periphery, flattish on base; aperture narrowly rhomboidal, acutely angled behind, produced downwards and inwards in front; columella a little oblique, arcuate, its plait distinct and a little below insertion; inner lip narrowly callused; outer lip straight.

Height, 2.1 mm.; width, 0.95 mm. (holotype).

Locality: Clifden, Southland, band 6A (Hutchinsonian).

Type in Auckland Museum (ex writer's collection).

Easily distinguished from *gorensis* by its lack of spiral sculpture, less stumpy habit, rather differently shaped aperture, and less marked angulation of body-whorl.

## Mosquito Life in the Auckland District.

### REPORT OF THE AUCKLAND MOSQUITO RESEARCH COMMITTEE ON AN INVESTIGATION MADE BY DAVID H. GRAHAM.

[*Manuscript received by the Editor, July 15, 1935; issued separately, September, 1939.*]

THIS report presents the results of an investigation into the Mosquito life of the Auckland district.

The research was originally started by Dr. David Miller in 1918, but his many duties prevented him carrying the work to a conclusion.

The Auckland Mosquito Research Committee was formed to organize and carry out the work and Mr. D. H. Graham was appointed Research Officer. The immediate objects of the research were:—

- (1) The determination of the species of mosquito present in the district.
- (2) Their seasonal and geographical distribution.
- (3) The conditions affecting their life.
- (4) Possible measures of control.

The investigation extended over a period of three years, from Mercer in the south to Kaitia and Spirits Bay in the north. The research was carried out by Mr. David H. Graham, and comprised systematic study (Graham, *Trans. N.Z. Inst.*, vol. 60, pp. 205–244, 1929), field work, experimental breeding and culture of mosquitoes, and other laboratory work carried out at the Auckland Museum, where accommodation was provided by the Council.

The study was under the supervision of Mr. Gilbert Archey, Director of the Museum, a member of the Committee.

The expense was borne by grants from the New Zealand Institute and the New Zealand Government Departments of Health and of Scientific and Industrial Research.

The Committee has to express thanks and appreciation to the officers of the Forestry Department and to the Sanitary Inspectors for their willing co-operation and assistance, particularly to the late Mr. C. Weaver for his assistance in examining overseas vessels.

The results of the work are of importance in two respects. We now possess a detailed knowledge of the life history of the mosquitoes of the northern part of New Zealand. Further, the report furnishes a basis for the action of Health Authorities in the suppression of a pest to human beings and stock, and assistance in combating the danger of the introduction of disease-bearing mosquitoes from overseas.

On these grounds the Committee feels that the research has been amply justified.

A. P. W. THOMAS, Chairman.

### 1. *Culex pervigilans* Bergroth.

1889. *Wiener entom. Zeitung*, p. 295.

This, the commonest New Zealand species, is endemic and occurs throughout the country, but is most abundant near habitations. It is a nocturnal biter and hovers for a long time before biting, emitting a high, loud, singing note much louder than any other species. Its bite, however, is generally much less severe than that of other species.

It is distributed throughout New Zealand, and in Auckland breeds at all seasons, even during the short warm periods which occur during winter. It is almost unrestricted in its choice of breeding-place, in which it differs from all other New Zealand species. It breeds in practically every place in which water can collect and remain unevaporated for even a short time.

Adult females usually retreat to the shelter of buildings, especially of cellars or unfrequented darkened rooms, between May and August; nevertheless egg-laying adults have been found in the city and suburbs all through the winter.

The larvae of *C. pervigilans* are able to "carry over" during the winter in quite exposed situations, and have been observed actively swimming under ice, coming up to breathe at the air spaces which often form. In fact, the distribution of *C. pervigilans* in the Auckland district seems to be restricted more by higher temperatures than by lower, for as we go north it is increasingly replaced by *Taeniorhynchus iracundus*, being completely supplanted in pools with a temperature of over 70° F.

### 2. *Culex fatigans* Wiedermann.

1828. *Ausseroeurop. Zweifl. Insekt.*, I, p. 10.

A species of world-wide distribution occurring in New Zealand only in and about Auckland City and Whangarei and therefore believed to be introduced. Bites at night and breeds through the year in any place exposed to full sunlight and holding water charged with decaying organic matter.

As with *C. pervigilans*, adults of *C. fatigans* have been found breeding and biting all through the winter, and the larvae have been observed to continue their development, even to pupating and emerging as adults in June. Curiously, however, adults could never be found in early spring (September and October) and it would seem that the months of July and August are cold enough to kill them off and that the species survives from year to year through the hibernating larvae.

### 3. *Culex annulirostris* Skuse.

1888. *Proc. Linn. Soc. N.S.W.* (2), iii, p. 1737.

An East Indian and Western Pacific species discovered (May, 1929) breeding in the hold of s.s. Tofua on arrival at Auckland from Suva, live larvae being subsequently discovered in a barrel on the waterfront. It is hoped that the destruction of this brood has prevented the establishment of the mosquito in New Zealand.

#### 4. *Taeniorhynchus iracundus* (Walker).

1848. *List Diptera Brit. Mus.* (1), 6.

An endemic species found only in Auckland Province in scrub and bush areas. It is a persistent night-biter and is especially troublesome around farms, where it pesters the stock. Breeding has been observed from December to May, but hibernating females have been seen sheltering under fern and *nikau* leaves: the males probably die off after fertilizing the autumn brood of females.

It does not begin to lay eggs until the water is about 65° F. The eggs so laid, however, will continue to develop when the temperature drops to 60° F., but development is suspended below that. This species favours water of a higher temperature than the other New Zealand species. At Spirits Bay larvae were abundant in pools in sunny sheltered creek-beds with a temperature of 85° F., and heavily charged with strong-smelling decaying vegetation. In summer these pools became too hot and putrid for the welfare of the "native trout" (*Galaxias fasciatus*), which died after endeavouring to escape by jumping out of the water.

#### 5. *Taeniorhynchus tenuipalpis* Edwards.

1924. *Bull. Ent. Research*, 14, p. 366.

An endemic species confined to scrub and bush areas of the Auckland Province, where it annoys bush campers at night. Beyond two records of egg-laying, Waimauku (January) and Piha (May) no information is available as to its breeding.

#### 6. *Aedes notoscriptus* Skuse.

1888. *Proc. Linn. Soc. N.S.W.* (2), 3, p. 1738.

An East Indian, West Pacific and Australian species, occurring in New Zealand only around Auckland city, Nelson city, and Whangarei. On this account and because of its having been more than once taken alive on vessels on their arrival at Auckland from Sydney, this mosquito is believed to be a recent introduction. It is essentially a day-time biter. It breeds during the summer and only in the shade of trees or buildings, though hibernating adults may emerge and commence biting during a warm spell in the winter.

Gullies in Auckland, where all too frequently numbers of tins have accumulated among the scrub, are typical of its habitat. It has been found in shaded drains, catch-pits and waterholes, but it is usually restricted to leaf bases and holes in trees, and well-sheltered artificial containers on the ground.

It hibernates in both adult and larval stages, the former resting under tree-fern fronds from May to October, with occasional brief flights in any spell of unusually warm weather. Normally no adults emerge from the pupae from June to October, but some were once observed to emerge in September in exceptionally well sheltered warm situations in the Waitakere Hills, and once in the Grafton Gully in Auckland.

#### 7. *Aedes antipodeus* (Edwards).

1924. *Bull. Ent. Res.*, 10, p. 132.

An endemic species restricted to dense forest in Auckland Province. Adults are active throughout the year and bite at any time

of the day or night. The eggs are apparently not laid in water, but are deposited on slime or mud. Females have been observed laying eggs on damp mud in winter. If rain falls on such mud, development at once commences and continues to the pupal stage even though the temperature of the water be no higher than 42° F. The whole development has been completed in three weeks in water at 52° F. Larvae have been raised from both damp and dried mud; and dry pools from around which adults have been absent for a considerable period have been observed to abound with larvae within 24 hours after a fall of rain. This habit of "carrying over" a dry spell in the egg stage enables it to meet the uncertainty of an irregular and intermittent rainfall.

The lower temperatures at which this species continues its development may be associated with its more southern distribution, and also with the greater elevation at which it usually occurs.

8. *Aedes vexans* Meigen.

1820. *Syst. Besch. Eur. Zweifl. Ins.*, vol. 6, p. 241.

An East Indian, Western Pacific and Australian coastal species. The only record of it in New Zealand is that of larvae found in a tin of water jammed among rocks just above high tide at Russell in July, 1929.

9. *Rachionotomyia argyropus* (Walker).

1848. *List Dipt. Brit. Mus.*, 1, p. 2.

An endemic species recorded from Nelson, Wellington, Ohakune and Waitakere Hills. It seems definitely to be restricted to the native bush, but the tanks and barrels around bush cottages, in which alone it has been found breeding, can hardly be part of its native habitat, and its true native breeding place has yet to be discovered.

Apparently it breeds, and its larvae continue to develop, from November to May, the development being, however, suspended from June to October, when the adults also are completely quiescent, sheltering under the eaves of cottages, outhouses and sheds in the Waitakere Hills. Its larvae possess large anal gills plentifully supplied with tracheae which enable it to remain below the surface. This suggests that deeper pools or slow-moving streams may be the normal native breeding places. It is a night-biting species.

10. *Opifex fuscus* Hutton.

1902. *Trans. N.Z. Inst.*, vol. 34, p. 188.

An endemic species restricted to rocky parts of the coast and breeding in semi-saline pools just above high water and frequently splashed by the spray. The larvae are able to remain below the surface for unusually long periods. A night-biting species.

11. *Anopheles maculipennis* Meigen.

1818. *Syst. Besch. Zweifl. Ins.*, vol. 1, p. 11.

Recorded here because a live female of this transmitter of malaria was taken at Auckland on a ship from the East Indies on May 27, 1929, and another on September 4, 1929, on a ship from Samarang.

## SUMMARY.

Mosquito.	Source.	Habitat.	Breeding Period in New Zealand.	Bite.
<i>C. pervigilans</i>	Endemic	City and suburban	All seasons	Night
<i>C. fatigans</i>	Introduced	"	"	Night
<i>Aedes</i> <i>notoscriptus</i> }	"	"	Summer only	Day
<i>A. antipodeus</i>	Endemic	Country and bush	All seasons in wet weather	Day and night
<i>Taeniorhynchus</i> <i>iracundus</i> }	"	"	Summer	"
<i>T. tenuipalpis</i>	"	"	Unknown	Night
<i>Rachionotomyia</i> <i>argyropus</i> }	"	"	Summer	Night
<i>Opifera fusca</i>	Pacific Introduced, but not established }	Coastal	Summer	Night
<i>Aedes vexans</i>		Coastal	Unknown	Night
<i>Culex</i> <i>annulirostris</i> }				Day and night
<i>Anopheles</i> <i>maculipennis</i>		On ships only at Auckland		

## EFFECTS OF SALINITY.

Experiments with larvae of *C. pervigilans* showed that while the sudden addition of twice the volume of sea-water to a given quantity of fresh water killed all larvae within 48 hours, they would survive in water brought gradually up to this salt content. Gradual addition of the sea-water produced no effect till the added sea-water exceeded the fresh, but most larvae survived until after the mixture had become more than two of sea-water to one of fresh.

Of greater interest was the effect of salinity on the pupae. When the added sea-water was double that of the fresh, the maturity of the pupae was hastened, and all hatched out almost immediately. For example, in one experiment with 70 larvae and 50 pupae, while all the larvae died within 24 hours, all the pupae changed to adults in the same period. The pupae in control jars, however, kept in similar conditions of light and temperature, changed to adults at the rate of one or two per day, as normally happens in winter, during which this experiment was made.

Apparently the increase in salt-content caused the acceleration of the change from pupa to adult, and this suggests in the drying of a pool containing mosquito pupae, the increase in the percentage of salts thus brought about is one of the factors in hastening the change to the adult condition, another factor being the increased rise in water temperature of a pool exposed to sun. The advantage to the mosquito of hastened development in a drying pool is obvious, and such accelerated development was frequently observed in the field.

## DESICCATION.

(Mosquito life in drying pools.)

Experiments with larvae and pupae of *C. pervigilans* showed that they were able to survive for over a week in merely damp conditions, such as the mud of pools or damp vegetable debris. Under

such conditions the pupae changed to adults in two hours instead of the normal two or three days and practically all the larvae in the last instar (i.e. 4th) at once pupated and were ready for the final change before the pool became dry. Larvae in the earlier stages (1st and 2nd) would, however, be unable to pupate and would perish when the damp material became dry. In another test, with the larvae in mud at 62–64° F., 20 per cent. survived three days' drying; at 72° F. all died in three days.

From the point of view of control measures these observations indicate the necessity of clearing, as well as draining, pools and blocked water-courses.

#### EFFECT OF WATER IMPURITIES.

The amount of organic matter in the water naturally influences the rate of development of larvae of *C. pervigilans*, which were found to require 41 days to reach the adult stage in tap water, but only 18 days when some liquid manure was added.

On one occasion *C. pervigilans* was found breeding in a wash-tub containing suds left in to prevent cracking. The fluid contained washing soda and soap. This is only a degree less remarkable than their breeding in sal ammoniac tanks and in bark tannin solution, both of which have been observed.

#### NATURAL ENEMIES.

The chief natural enemies of the mosquito in the Auckland district were found to be the following:—

Among the birds, the native fantail (*Rhipidura flabellifera*) and the native tomtit (*Petroica toitoi*).

Among lizards, the green gecko (*Naultinus elegans*).

At certain seasons frogs destroy enormous numbers of mosquitoes in the pupal stage. The stomach contents of dissected frogs showed all the stages from egg to adult, but always far more pupae. Tadpoles were not observed to eat larvae.

Among fishes, the "native trout" (*Galaxias fasciatus*). The repeatedly observed absence of mosquito larvae from streams inhabited by *Galaxias fasciatus* indicated this fish as an active natural enemy of mosquitoes and a promising control agent. This was successfully tested both in the laboratory and field. In the laboratory the fish were observed voraciously devouring all the larvae supplied to them. In the field test, a well was used which contained about 800 larvae to the pint of water. Eight of the fish were introduced: the next day the larvae were nearly all destroyed, and none were to be found on the third day. The fish kept the well free from larvae for the following two months that it was kept under observation. On one occasion several hundred larvae were transferred to the well, but the fish devoured them all within 24 hours.

Clearly the "native trout" is a valuable controlling agent and could, with advantage, be transferred to mosquito-infected swamp drains and streams.

The carp (*Cyprinus carpio*) and goldfish (*Carassius auratus*) were found to be of special value in the ponds and fountain-basins in and about Auckland. They eat the eggs, larvae, and adult mosquitoes.

Every garden pool should be provided with carp or goldfish.

The active little native bully (*Gobiomorphus gobioides*) feeds eagerly on mosquito larvae, and as it is common in small creeks and ponds, no doubt helps to keep the number of mosquitoes in check. At Bethell's, on the West Coast, a lake well-stocked with *G. gobioides* was quite free from mosquito larvae, as were several creeks at Rawene (Hokianga) where the "bully" was abundant. At Herekino, a barrel of water swarming with eggs, larvae and pupae was completely cleared within a day by the introduction of a few "bullies."

The top minnow (*Gambusia affinis*) is a native of the United States and inhabits shallow and sluggish waters. Its value in the control of mosquitoes has been established in many parts of the world.

In 1928, Dr. T. W. Hughes, Medical Officer of Health for Auckland, obtained 43 specimens from Hawaii for experimental purposes. Within 10 days they commenced to die, and in spite of changes of water and every care they were all dead in three weeks.

In the United States these fish require a good deal of attention and thrive only in suitable waters and conditions, and even if established in New Zealand, would have to compete with our native Galaxiads and bullies. The most likely places in which they might be of service are the large areas of shallow swamp waters.

The "water-bug" (*Anisops assimilis*) and the "water-beetle" (*Rhantus pulverulosus*) which are common in ponds, troughs and tanks, are very vigorous natural enemies of mosquito larvae.

Experiments showed that *Anisops assimilis* takes the larvae greedily, but will attack the pupae only when larvae are absent, and even then slowly and reluctantly. Field observations also have shown that in pools or troughs stocked with *Anisops assimilis* the larvae do not even reach the pupal stage: indeed, very few reach the third instar. A field observation, frequently made, shows that although water troughs for horses and cattle usually contain "water-bugs" which keep them free from mosquito larvae, the puddles made beside them by the visiting animals' feet are not permanent enough to maintain this control. Nevertheless, these pools last long enough to permit a mosquito brood to come to maturity, and we here get the significant occurrence of larvae in a temporary puddle and their absence from a permanent water-container, the latter, however, containing an energetic mosquito enemy. These conditions apply chiefly to troughs in country towns, those in public thoroughfares in larger towns being usually without predatory insects and therefore requiring to be emptied once in 10 to 14 days.

The aquatic larva of the beetle *Rhantus pulverulosus*, which inhabits a variety of ponds, pools and artificial containers, also attacks the mosquito larvae by sucking out the body contents, and it was observed that four *R. pulverulosus* larvae could, between them, devour 100 mosquito larvae within two days.

The "water-boatman" (*Arctocoris arguta*) also preys on mosquito larvae, but not so actively as *Anisops* or *Rhanthus*.

Dragon flies take mosquitoes of both sexes in the North of Auckland, where *T. iracundus* is common: while in the Aupouri Peninsula, where vast swarms of *T. iracundus* are on the wing by day and night, dragon flies catch enormous numbers. The remains (genitalia and hypopygia) of as many as 20 mosquitoes were found in the stomach of one small dragon fly, and a specimen of the larger *Aeschna brevistyla* contained 27. They did not, however, appear to be as active controlling agents as *Rhanthus* and *Anisops*.

Two species of spiders and a slim, long water-spider have been observed catching and devouring adult mosquitoes, and one of the Hydrachnia, a minute red mite, has been seen attaching itself to the thorax of the larva, the cephalothorax of the pupa and the abdominal segments of the adult.

A pool in the Hokianga district was found to contain *C. pervigilans* larvae, which were covered, especially on the thorax and eighth abdominal segment with large numbers of a protozoon, apparently a species of *Porodon*. All the larvae were thin and wasted and there were no pupae found.

#### MOSQUITOES IN RELATION TO DOMESTIC ANIMALS.

The results of investigations verified the frequent statements of farmers that mosquitoes attack their dairy herds, that the annoyance to the cows is so great that milking must be done before dark, and that the fattening cattle and dairy cows stampede into the manuka scrub to brush the pests away. The parts of the animals attacked were the udder, and about the tail, the ears and the eyes.

Poultry, pigs and sheep were also found to be attacked.

From Auckland to the far North, undeniable evidence was collected showing that mosquitoes not only attack live stock, but do so in preference to human beings. At milking time on the farms it was the cows, not the milkers, that suffered. If mosquitoes were numerous and the livestock had access to and wandered about the immediate vicinity of the residence, the inmates were little troubled: in the absence of livestock in the neighbourhood of the house, the inmates were plagued by the mosquitoes.

#### CITY AND SUBURBAN AREAS.

The mosquitoes concerned are *Culex pervigilans*, *C. fatigans* and *Aedes notoscriptus*.

*C. pervigilans* may be described as the house and garden mosquito, and can be found breeding in every conceivable type of pond, drain, puddle or receptacle containing clean or polluted water.

*C. fatigans* is the street and gutter mosquito, breeding chiefly in barrels or pits containing liquid manure, in pools filled with seepage from manure heaps or decomposing refuse and in streams such as Motion's, Cox's and the Newmarket-Parnell creeks, which sometimes carry sewerage overflow.

*Aedes notoscriptus*, the mosquito of gardens and gullies, is more selective in its choice of breeding place. It never lays its eggs where direct sunlight strikes, but makes use of a great variety of water containers and occasionally of street gully-traps, provided they are screened by grass, scrub or trees, and of drains on the sunless side of buildings.

This generalization is by no means exact: there is overlapping of breeding places, and all three mosquitoes might be found together in such a suitable spot as in foul water under the shade of trees. (Pl. 19, fig. 1.)

A very considerable, if not the greater proportion of mosquitoes which disturb residents, is bred in their immediate neighbourhood, in fact, on their own premises. It was a daily experience, while studying the city conditions, to demonstrate this to surprised people, in every part of the city and suburbs.

The remedy is in their own hands. Permanent garden ponds should be stocked with goldfish or *Gambusia*: water tanks or barrels should be covered, guttering or spouting should be kept clean and in repair, washtubs and similar containers should be emptied every week or ten days and gully-traps should be treated with an ounce of powdered bluestone (copper sulphate) or with kerosene, waste oil or disinfectant. Liquid manure should be screened or made up in small quantities for immediate use.

A few drops of oil should be placed in the bases of banana palms and, most important of all, long grass or weeds should be scythed or rooted out and the tins and rubbish which will almost invariably be revealed, cleared up.

#### BUSINESS PREMISES AND INDUSTRIAL AREAS.

Many of the commercial houses in Auckland have drains round the sides and backs of buildings to carry rain water to the gully-traps. Frequently these were found to be blocked by a small quantity of earth or debris and enormous numbers of mosquitoes were breeding in the small pool thus formed. One drain, 9 inches across, 3 inches deep, and 50 feet long was found to contain 200,000 mosquito larvae and pupae; a couple of broom-sweeps would have removed the small obstruction and swept away the developing mosquitoes.

All too frequently, tins and other containers, old tyres and similar rubbish are thrown out into the warehouse yard and left "until there is enough for a load." Meanwhile thousands of mosquitoes are bred out.

In industrial yards, private, municipal and government, there are usually numbers of casks, barrels, oil drums and bitumen tins which hold rain water and form ideal breeding places for *C. per-vigilans*. (Pl. 19, fig. 2.)

Garages, construction shops and railway yards all have a litter of old cars or their parts, engine cabs and trucks (pl. 19, fig. 3); boat-building yards have oil and paint tins lying about and old boats and launches. All these can hold enough water for breeding innumerable mosquitoes.

Sweeping gutters and drains weekly and the frequent removal of rubbish would clear the city business premises; while in industrial and other yards barrels should be upturned or screened, and such spare parts as cannot be punctured or upturned should be sprayed with oil or copper sulphate—particularly the latter, as it would remain on the receptacle for some time.

Fire buckets almost invariably contain mosquito larvae, particularly on suburban railway stations. A copper sulphate or other insecticide should be regularly used therein.

#### MUNICIPAL AREAS.

The street gully-traps frequently are most prolific breeding places of mosquitoes. Again and again enormous numbers have been found breeding in them. Repeated observations have shown that though the frequent flushings from heavy rains certainly reduce the number of larvae and pupae, sufficient are always left to provide for a constant emergence of adult mosquitoes through the summer and autumn. The remedy is the frequent clearing of leaves and other rubbish, to be followed by treatment with a larvicide such as copper sulphate. Oil may be ineffective through not being sufficiently evenly sprayed to form a complete film, and even if a film be formed, it will easily be broken by rain or by litter falling into the gully-trap. A female mosquito will not lay her eggs on an oiled surface: she will find some other place. She will, however, deposit her eggs in water treated with copper sulphate and the larvae that emerge will die.

Horse troughs sometimes contain enough predatory insects to control the mosquito, but this should not be relied on and they should be emptied and cleaned fortnightly.

As in private gardens, goldfish or carp should be introduced into fountains, ponds and streams; garden water-containers should be cleared away, and holes should be made in the corners of the water-holding recesses of guns and ammunition wagons displayed as war trophies. In the cemeteries, the flower vases and containers should be emptied periodically.

#### DUMPS, VACANT SECTIONS, CREEKS AND WATER-COURSES.

The several gullies or depressions, to fill which permission is given for the dumping of rubbish of all kinds, are under present conditions a continual source of mosquito infestation. In such places every conceivable type of water-holding receptacle was found. (Pl. 20, figs. 1 and 2.) The breeding of mosquitoes in a dump can be so easily prevented by the simple expedient of ensuring that all tins thrown into it shall be rolled or beaten flat, that this should be made a strict condition of the use of a municipal dump or of the establishment of a private one. Regulations should be framed, or when they are in existence, enforced, to prevent rubbish being dumped in an unauthorised place. Generally such litter in itself bears evidence of its origin, as the labels withstand obliteration for a few weeks at least and so would give a vigilant inspector time to discover and investigate the offence.

As for vacant sections, the residents have the matter very largely in their own hands. Lack of ordinary community considerations may perhaps not deter them from littering a neighbour's vacant section with rubbish, but for their own comfort they should appreciate that from every tin they throw over a neighbour's fence a swarm of mosquitoes may return to pester them. Business firms are not without blame in this matter, for several sections were found to contain garage litter, large numbers of tobacco tins, and tins of other "packed" commodities. Carriers, too, who have been commissioned to take a load from a commercial house to a Council dump, sometimes deposit the rubbish in a more convenient gully or section. Grass and weeds soon grow over this litter, the tins fill with water and a severe mosquito infestation results. Inspectors could help to disclose the all-too-common vacant section nuisance by ordering the scything and burning of the rank growth of weeds thereon.

The slow-moving marshy creeks running into the small lakes around Auckland and the larger creeks which become sluggish in autumn breed large numbers of mosquitoes. The remedy is to trim the sides of the creeks and remove the weeds in order to maintain a continuous flow of water. In cases in which this is ineffective, it will be necessary to treat them with a strong solution of copper sulphate at various places from the source to the mouth. Artificial means have to be used when the presence of much sewage or organic matter inhibit the life of natural enemies such as fish and insects.

#### COUNTRY DISTRICTS.

In country towns the mosquitoes concerned are *Culex pervigilans* and *Taeniorhynchus iracundus*; in the country proper *C. pervigilans*, *T. iracundus* and *Rachionotomyia argyropus*.

On the whole, country towns suffer from the mosquito pest through conditions similar to those that prevail in the cities. The smaller towns which have no street gully-traps have a considerable growth of weeds and grass in their streets and in their semi-rural outskirts. One large northern town was in a particularly bad state: almost every vacant section, backyard, embankment and rubbish tip was involved; dumps of 100 or more tins were found at the back or sides of commercial houses, bakehouses, etc., and the local body's rubbish dump was a vast breeding ground for mosquitoes. Vigorous action by the local authority has since rectified this state of affairs, greatly to the benefit of the inhabitants.

At Kawa Kawa *C. pervigilans* was breeding in large numbers in pools of water almost in the town, and adults were hatching out continuously from drains, tins, hoof-holes, etc. The residents were not much troubled, however, for cows graze in several of the streets and the mosquitoes apparently confine their attention to them. Imperfect and open drains, seepage pools, rain-water tanks or small reservoirs near the town, all provide further conditions for mosquito breeding. Russell, for instance, was found to be infested with mosquitoes all the year round; the residents depending on uncovered rain-water tanks for their water supply.

Country hotels often unwittingly provide means for breeding mosquitoes that annoy the guests and staff. Some, which lack a proper water supply, have in the yard barrels of water for washing and scrubbing. They are invariably uncovered and breed swarms of mosquitoes. In one hotel whose guests were loud in their complaints of mosquito pestering, the source of annoyance was traced to a 10-gallon drum of water in the privy. This drum was estimated to be breeding 20,000 mosquitoes a month. The addition of lysol, a teaspoonful to the gallon, put a stop to the nuisance immediately. Other causes of trouble were horse-troughs, scalding-troughs, blocked roof guttering or spouting, and bedroom water-jugs and flower vases.

Every group of farm buildings offers almost as great a variety of breeding places as exists in towns, but farm residents are rarely troubled by the mosquitoes, which devote practically all their attention to the dairy stock and poultry.

Country roads are often flanked by blocked or partly-blocked drains, by neglected water-tables, or by borrow-pits which become prolific breeding places.

The holes left by kauri-gum diggers positively teem with mosquitoes, particularly when scrub has been allowed to grow round them and provide shade.

The borders of lakes and lagoons provide breeding grounds round their edges. The most extensive mosquito breeding conditions, however, are usually those provided by interference with, or alteration of, the natural conditions through road-making and other constructional work.

The conversion of swamps and "gum-land" into agricultural land by drainage schemes is contributing enormously to the elimination of the mosquito problem in many country districts. This is well illustrated in the neighbourhood of Kaitaia and Te Kao.

In country towns and around country houses much the same control measures are required as in the towns.

There may be blocked drains and channels, swamp areas, blocked water-tables and borrow-pits that need clearing or draining and open water reservoirs that should be stocked with native trout. Probably nothing but draining and cultivation will stop the nuisance in dug-over "gum" country.

#### THE INTRODUCTION OF MOSQUITOES FROM OVERSEAS.

Two mosquitoes, *Culex fatigans* and *Aedes notoscriptus* have been found in New Zealand only in vicinity of the overseas ports of Auckland, Whangarei and Nelson, from which it may be fairly inferred that they have been introduced since European occupation.

In the case of *A. notoscriptus* there is evidence that the conditions exist for its repeated introduction into Auckland from Sydney, and that it is still being introduced. As it is already well established here, the introduction of a few more from time to time may not be of great importance. The danger lies, of course, in the possible introduction of a disease-bearing species from overseas, a possibility rendered more likely in view of the recently-established malaria-carrying propensity of a Sydney species.

The duration of the voyage from Sydney to Auckland is entirely in favour of imported mosquitoes breeding here, for the usual, though not invariable, procedure of a female after emergence is for it to be fertilized, then to seek blood for the development of the eggs, and within one or two days to settle down and remain quiescent for three or four days before seeking water in which to lay the now mature eggs.

The four or five days' trans-Tasman journey is just sufficient for this normal procedure, and female mosquitoes on arrival in Auckland would be ready to fly ashore seeking water in which to breed.

Between May and November, 1929, an examination was made of a number of vessels arriving at Auckland from New York, Cuba, Singapore, Sydney, Suva, Niue, and Rarotonga. Officers and seamen on several of these vessels stated that they had been pestered by mosquitoes for several days after leaving tropical ports. Officers of the s.s. *Lambeth*, from Cuba, stated that whenever they have called there during the wet season, when mosquitoes are particularly numerous, they have been troubled with them for at least ten days after sailing. Firemen on the s.s. *Waipahi*, from Rarotonga, said they were pestered during the whole ten days' voyage to Auckland. Numbers of the crews of other ships made similar statements, some adding that after a few days out the mosquitoes did not bite, but remained settled on the walls, ceilings or curtains.

On the 24th May, 1929, the s.s. *Maunganui* was inspected immediately on its arrival at Auckland from Sydney and three live *Aedes notoscriptus* were secured, one in the vegetable house on the upper deck, and two between decks where horses had been accommodated on the voyage.

On the 10th June, 1929, on the s.s. *Ulimaroa*, from Sydney, two live female *A. notoscriptus* were caught in No. 2 hold. On the same day on the s.s. *Tofua*, from Fiji, a half-barrel with over an inch of water at the bottom was found in between decks of the No. 2 hold, in which there were several thousand larvae and pupae of *Culex annulirostris*, and from which adult mosquitoes were continually emerging.

*C. annulirostris* is a common Fijian and New Hebridean species which, fortunately, is not a disease carrier. It is, however, a persistent biter that breeds in a variety of situations, including water of considerable salinity. Two months later a barrel containing water in which a considerable number of larvae of *C. annulirostris* were actively swimming was discovered on the waterfront, about 300 yards west of the berthing-place of the s.s. *Tofua*. (Pl. 20, fig. 3.) The larvae were all secured and preserved, and a thorough though fruitless search was made in other receptacles along the waterfront in which they might be breeding.

This case illustrates the danger of water-containers on the waterfront as giving opportunity for live mosquitoes brought by ships to commence breeding here, and also shows that even our two coldest months, July and August, are not too severe for the larvae and adults of tropical species to withstand.

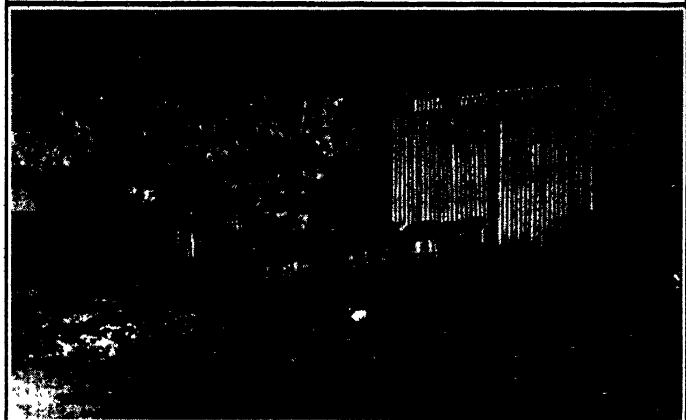


FIG. 1.—Pool: *C. perrigilans* breeding throughout the year; *T. iracundus* from January to May.

FIG. 2.—Foundry Yard on Waterfront, Auckland. *C. perrigilans* breeding in barrels.

FIG. 3.—Railway Yards, Auckland. Breeding places.



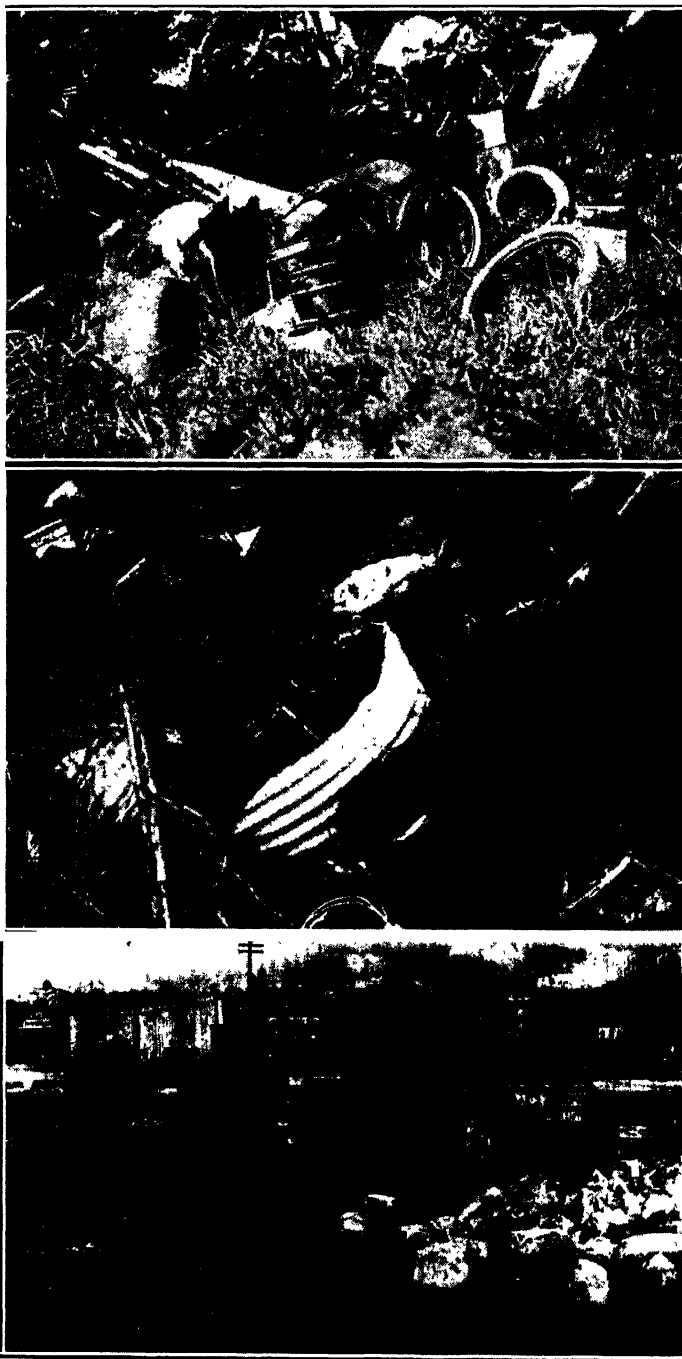
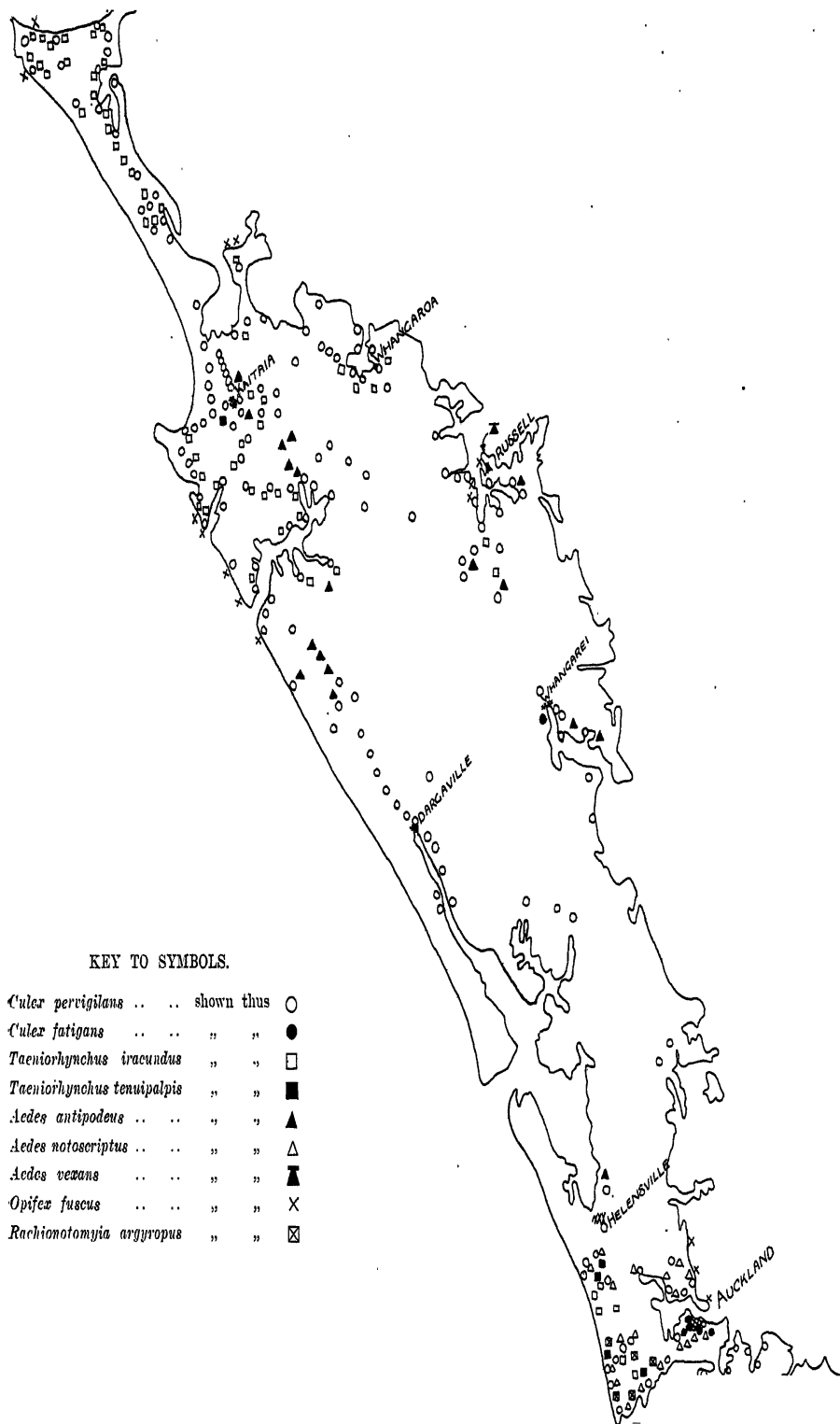


FIG. 1.—Council Dump. Bassett Road, Remuera.

FIG. 2.—Municipal Dump. Great North Road.

FIG. 3.—Barrels on Auckland Waterfront. *C. annulirostris* breeding.





# KEY TO SYMBOLS.

<i>Culex pervigilans</i> .. ..	shown thus	○
<i>Culex fatigans</i> .. ..	" "	●
<i>Taeniorhynchus iracundus</i> .. ..	" "	□
<i>Taeniorhynchus tenuipalpis</i> .. ..	" "	■
<i>Aedes antipodens</i> .. ..	" "	▲
<i>Aedes notoscriptus</i> .. ..	" "	△
<i>Aedes vexans</i> .. ..	" "	▼
<i>Opifex fuscus</i> .. ..	" "	X
<i>Rachionotomyia argyropus</i> .. ..	" "	⊠



The importance of this will be realised in connection with the following two cases:—

On May 27, 1929, a live female *Anopheles maculipennis*, a transmitter of malaria, was secured in between decks on the s.s. *Sussex*, from Singapore. It was in a quiescent state and there was no blood in its stomach. A fire had occurred on the voyage and no doubt smoke had penetrated the holds, so possibly other individuals of *A. maculipennis* had either been driven away or killed.

On September 4 of the same year, a live female *A. maculipennis* was caught on the s.s. *Narbada*, from Samarang. Another was seen but not secured. These were found in the insulated holds, which, when loaded with rice and sago at the eastern ports, are closed down for the voyage. The holds are not refrigerated and maintain temperatures between 71° and 81° F., thus providing ideal conditions for the survival of tropical mosquitoes during the long voyage.

We do not know if these disease-bearing mosquitoes would be ripe for breeding after a long voyage, but if both sexes should arrive together the conditions for their establishment certainly exist, at present, on the Auckland waterfront.

In view of these ascertained facts—that mosquitoes certainly do arrive at Auckland from overseas, that introduced mosquitoes have been breeding on the waterfront, and that conditions in North Auckland are suitable for their establishment—it is urged that active measures be taken by the authorities to prevent their introduction and to ensure that the waterfront be kept clear of all receptacles which could contain water in which they could breed.

#### KEY TO THE SPECIES STUDIED.

Five genera and ten species were recorded during the investigation; they may be distinguished as follows:—

- |   |                                   |
|---|-----------------------------------|
| Legs brown with pale buff spots at apex of femora and tibiae. . . . .                                       | Genus <i>Culex</i>                |
| A row of dark spots underneath the abdomen  | 1. <i>C. pervigilans</i> Bergroth |
| No dark spots underneath the abdomen; proboscis wholly black. . . . .                                       | 2. <i>C. fatigans</i> Wild        |
| Proboscis with a white band centrally situated. . . . .   | 3. <i>C. annulirostris</i> Skuse  |
| All three femora pale buff, other joints dark brown. . . . .  | Genus <i>Taeniorhynchus</i>       |
| Thorax with one long median and two shorter submedian straight lines. . . . .                               | 4. <i>T. iracundus</i> Walker     |
| Thorax with two straight submedian and two curved lateral lines. . . . .                                    | 5. <i>T. tenuipalpis</i> Edwards  |
| Most leg-joints with white bands at apex, giving the legs a white spotted appearance. . . . .               | Genus <i>Aedes</i>                |
| Thorax with several curved longitudinal lines.  | 6. <i>A. notoscriptus</i> Skuse   |
| Thorax with several straight longitudinal lines. . . . .  | 7. <i>A. antipodeus</i> Edwards   |
| Thorax entirely black. . . . .  | 8. <i>A. vexans</i> Meigen        |
| Joints of the tarsi white-banded, giving the mosquito the general appearance of being white-footed. . . . . | Genus <i>Rachionotomyia</i>       |
|   | 9. <i>R. argyropus</i> Walker     |
| Legs and body entirely black. . . . .   | Genus <i>Opifex</i>               |
|   | 10. <i>O. fuscus</i> Hutton       |

## SUMMARY.

Mr. Graham's investigation has disclosed the following interesting points.

*Aedes antipodeus* lays its eggs in mud, in which they survive even when it dries, until rain falls and development is enabled to proceed.

The effect of salinity of the water is to hasten the maturity of the pupae of *Culex pervigilans*. When two parts of sea-water were added to one part of fresh water containing 50 pupae, all the pupae changed to adults within 24 hours.

The endemic forest species, *Rachionotomyia argyropus*, was found breeding only in water tanks in the Waitakere Hills. The larvae possess anal gills as well as a siphon, so are able to remain below the surface of the water. Apparently its undiscovered breeding places are deep pools and streams.

*Culex pervigilans*, which may be termed Auckland's mosquito enemy No. 1, is characterized by its wide variety of breeding places and the length of its breeding season.

Several species of New Zealand mosquitoes inflict bites that are irritating to most people and cause loss of sleep, and two of them, *Culex fatigans* and *Aedes notoscriptus*, cause very painful bites which may result in severe inflammation and occasionally in serious illness.

The two mosquitoes which are intolerable nuisances in Auckland city and suburbs are the native *Culex pervigilans*, the night-biter, and the introduced *Aedes notoscriptus*, the daytime biter.

One disease-bearing species, *Culex fatigans*, was found only in and about Auckland and Whangarei, but has also been reported from Nelson. It was probably introduced from overseas and is now established here. This mosquito can transmit filariasis (common in Fiji and Samoa), but not malaria or yellow fever.

With the exception of *Culex fatigans* and of a few *Anopheles maculipennis* (a vector of malaria) found in the holds of two ships from Singapore and Samarang respectively, no evidence was found of any mosquito capable of transmitting disease.

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**Occurrence of *Dasypodia selenophora* in Southland.**

By J. H. SORENSEN.

[Read before the Southland Branch of the Royal Society, November 24, 1938; received by the Editor, December 22, 1938; issued separately, September, 1939.]

DURING 1937-38 the Province of Southland enjoyed a very warm and dry summer, followed by a comparatively mild winter and warm spring. Undoubtedly the climatic conditions were beneficial to various forms of insect life, and from being sufficiently noteworthy to attract newspaper paragraphs last summer, the white butterfly (*Pieris rapae*) has now increased in numbers so as to become almost common with the advent of the 1938-39 summer.

Various species of the family of Elateridae are to be found everywhere in increasing numbers, and the lighting of fires at night to attract and destroy the night-flying *Porina* moths was advocated by the Provincial Executive of the Farmers' Union (*Southland Times*, 29/10/38). The larvae of the Diamond-back moth (*Plutella maculipennis*) took a heavy toll of the field crops and the vegetable gardens last summer, but have not made an appearance yet this year.

***Dasypodia selenophora*. Guenée.**

My attention was first drawn to the occurrence of this moth by a paragraph which appeared in the *Southland Times* of 22nd October, 1938. This read: "An unusually big moth of striking colouring was brought into the *Times* office yesterday. It was found on the property of Mrs. Pont, Colac Bay. With a wing-spread of nearly two inches, the moth was of a rich dark brown colour, and on each wing was a distinct blue ring."

On 25th October I received three specimens—one from Ryal Bush, one from Otatara, and one from Invercargill. On the 26th another was reported to me from Kew. On the 28th two more, and on the 29th I found one in my own room in South Invercargill at 10 p.m. Other specimens were forwarded to the Southland Museum, and the table below gives the date, locality and number:—

22/10/38	<i>Times</i> report of Colac Bay specimen ..	..	..	1
25/10/38	Ryal Bush, Otatara and Invercargill ..	..	..	3
26/10/38	Kew specimen reported ..	..	..	1
28/10/38	Castle Rock and Invercargill ..	..	..	2
29/10/38	Invercargill ..	..	..	1
30/10/38	South Riverton ..	..	..	2
31/10/38	Glencoe ..	..	..	1
2/11/38	Invercargill ..	..	..	1
3/11/38	Waikiwi ..	..	..	1
4/11/38	Wyndham ..	..	..	1
5/11/38	Awarua ..	..	..	1
6/11/38	Invercargill ..	..	..	1
7/11/38	Mokotua ..	..	..	1
8/11/38	Shown two and received report of several others, all from Invercargill ..	..	..	2
10/11/38	Balfour ..	..	..	1
12/11/38	Invercargill ..	..	..	1
17/11/38	Kew, two specimens; a third received by post without any name or locality ..	..	..	3
19/11/38	Shown three more by Dr. Burns-Watson, of Invercargill, collected by his son, who reported two others ..	..	..	5
Total ..				20

Thus it will be seen that over a period of between three and four weeks the moth has appeared in many parts of Southland, and I was told by a workman from the Milford Sound District that the moth was fairly common in that locality.

In the Southland Museum collections are six specimens of *D. selenophora*, but no record exists to say where they were obtained, by whom, or on what date. Four of the six mentioned are in the Pascoe collection and may have been obtained locally many years ago, but must remain doubtful owing to lack of data.

#### REFERENCES.

Colenso records having witnessed the metamorphosis of *D. selenophora* (*Trans. N.Z. Inst.*, vol. 11, page 300).

Meyrick describes the moth in his monograph of the New Zealand Noctuidae (*Trans. N.Z. Inst.*, vol. 19, page 38) and gives localities "Napier, Richmond and Christchurch in January; apparently not common. Occurs commonly in Eastern Australia."

Hudson in his *New Zealand Moths and Butterflies*, 1898, pp. 35 and 36, gives localities Auckland, Napier and Wellington in the North Island and at Nelson, Richmond and Christchurch in the South Island, and further states that the perfect insect appears in January, February and March, and that it is rather a rare species.

Tillyard in his *Insects of Australia and New Zealand*, 1926, p. 443, states that the Noctuidae are not represented in New Zealand except by introduced species. He says that *D. selenophora* is common in Victoria and Tasmania and not uncommon in parts of New Zealand.

Hudson in his *Butterflies and Moths of New Zealand*, 1928, pp. 80 and 81, describes *Dasypodia* as an Australian genus probably of one species and states that the antennae in the male are ciliated. He gives as New Zealand localities "generally distributed throughout the North Island and in the South Island it has occurred at Nelson, Richmond, Hokitika, Christchurch, Invercargill and at Dog Island in Foveaux Strait. He says the larvae are fully grown about the end of January and the perfect insect appears in February, March and April, but is rather a scarce species. "Hibernated individuals are sometimes found in October and November, at which time the eggs are deposited."

#### SUMMARY AND CONCLUSION.

Apparently *D. selenophora* is not a native of New Zealand and must have been introduced from Australia originally.

The usual appearance of the moth is given as January, February, March and April.

Hudson says hibernated specimens are sometimes found in October and November, the months in which the present occurrence has taken place.

The larvae feed on *Acacias* and these trees are planted in many parts of Southland.

An examination of *Acacias* near and in Invercargill failed to reveal any larvae.

No *Acacias* are present in the Milford district so far as I am

aware, but the kowhai (*Sophora microphylla*) and various species of *Carmichaelia* represent the Leguminosae.

The antennae in the males are ciliated. All the specimens received at the Southland Museum are females and one deposited several scores of eggs in the tin in which she was confined.

The question arises as to how the present occurrence of this moth has taken place. Three solutions seem feasible and any one might suit the present case:—

1. That the moths may be hibernated individuals as described by Hudson. The dry summer of 1937-38 and the comparatively mild winter and early spring following would be favourable in this respect. The date of the occurrence is as given by Hudson.

2. That the moths may have arrived here by flight from Australia, in which case one would expect to find them in the Milford district, the nearest land in New Zealand to Tasmania and Eastern Australia.

3. That the eggs of the moth may have been introduced by some means and the resultant growth of the larvae and the metamorphosis taken place in this country. Hardwood poles from Australia are often landed at the Bluff, and the eggs, which are small and seed-like, could be introduced in this way.

Without further knowledge, the question must remain unanswered, and it will be interesting to see if a large hatch takes place from January on in 1939, for many moths must have had opportunity to deposit their eggs, and the number captured probably represents a very small percentage of the total present in Southland at this date.

#### *Addendum.*

Since writing the above I have received five more specimens on the following dates:—

22/11/38	Three specimens, one from South Hillend, and two from					
	Te Tua	..	..	..	..	3
24/11/38	Two from Gladstone	..	..	..	..	2

This brings the total up to 34, and Dr. Burns-Watson has reported to me of the presence of several more. I was also told by a friend that the conductor of the Children's Session at Station 4YA, Dunedin, has received a great many more from various parts of Southland and has been giving a radio talk on them during a part of the programme. I have since verified this report.

I was told about the same moth whilst on a visit to Stewart Island in March, 1939, and identified a specimen as *D. selenophora*. The time of the appearance on Stewart Island coincided with that on the mainland. Further evidence came to hand of the appearance of the moth in the Milford Sound district, but no specimens were forthcoming, although my informant described the moth and readily picked it out when shown a tray of mixed moths.

A close watch was kept in many parts of the Province during January, February and March of this year (1939), but no specimens were seen or heard of.

I tried to hatch out eggs laid by some of the specimens sent in to the Southland Museum, but was unsuccessful.

## Descriptive Notes on Some New Zealand Fishes.

By

GILBERT P. WHITLEY, F.R.Z.S.,

Ichthyologist, The Australian Museum, Sydney,\*

and

W. J. PHILLIPPS,

Dominion Museum, Wellington.

[Read before the Wellington Philosophical Society, May 26, 1937; received by the Editor, June 16, 1937; issued separately, September, 1939.]

THE present paper contains notes and descriptions of various species of New Zealand fishes which have been examined and discussed by us jointly. The holotype of *Eleotris huttoni* Ogilby = *Gobiomorphus huttoni* is now figured for the first time, and several new species are described.

### Family MYCTOPHIDAE.

Genus SERPA Cloquet, 1827.

#### *Serpa peccatus* sp. nov.

This new name is necessary for *Lampanyctus macropterus* of Regan (*Terra Nova Zool.*, 1, 4, March 25, 1916, p. 140, pl. 6; fig. 5) from Spirits Bay, North Cape, New Zealand. Regan's fish differs in the form of the suborbital, insertion of anal fin, fin-counts and probably also in myomere-counts from the true *Myctophum* (*Lampanyctus*) *macropterus* Brauer (*Zool. Anzeiger*, 28, Dec. 20, 1904, pp. 397 and 404, fig. 5) from the Indian Ocean.

### Family PARALEPIDAE.

Genus PRYMNOTHONOIDES nov.

Genotype, *P. regani* sp. nov.

Resembles a young *Paralepis*, but has only sixty myomeres and eleven anal rays. The adipose fin is, moreover, above the posterior end of the anal fin.

#### *Prymnothonoides regani* sp. nov.

"*Prymnothonus*" Regan, *Terra Nova, Zool.*, 1, 4, March 25, 1916, p. 138, pl. 7, fig. 3.

A remarkable fish from off Cape Maria van Diemen, caught in a depth of two metres, which has been left unnamed up to the present time.

### Family MURAENIDAE.

Genus SERRANGUILLA nov.

Genotype, *Gymnothorax prionodon* Ogilby (*Proc. Linn. Soc. N.S. Wales* (2), 9, 4, March 28, 1895, p. 720), said to have come from Port Jackson, N.S. Wales.

#### *Serranguilla prionodon* (Ogilby).

A new generic name is required for Ogilby's species, the saw-teeth being a distinctive feature. The type, in the Australian Museum, has been examined anew, although the salient characters of

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\* By permission of the Trustees of The Australian Museum.

the specimen, given by McCulloch, were recently quoted by Griffin (*Trans. N.Z. Inst.*, 56, 1926, p. 538, pl. 93) when figuring a New Zealand specimen.

Genus GYMNOTHORAX Bloch, 1795.

**Gymnothorax griffini** sp.nov.

*Gymnothorax meleagris* Griffin, *Trans. N.Z. Inst.*, 58, Sept., 1927, p. 138, pl. 10, fig. 2. White Island, Bay of Plenty, New Zealand.

This species, well described and figured by Griffin, is not the true *G. meleagris* of Shaw and Nodder (*Nat. Miscell.* 7, Sept. 1, 1795, pl. 220) from the "Southern Ocean," which has less elevated head, wider gape, and is of much smaller size. The dentition, according to Kaup, is quite different from that figured by Griffin. Richardson (*Voy. Erebus and Terror, Fish*, 1848, p. 93) also redescribed Shaw and Nodder's original specimen. We rename the New Zealand species after our late friend Louis T. Griffin, author of several valuable papers on New Zealand fishes.

Family GALAXIIDAE.

Genus GALAXIAS Cuvier, 1816.

**Galaxias castleae** n.sp. (Plate 21, fig. 1.)

The anal fin when laid back does not reach to procurent caudals and pectoral is half distance from its base to base of ventral. A typical fin formula is: D.2/7; C.18 (true rays); A.2/10; P.14; V.7. The eye is 4 in head and anal origin nearer snout than caudal extremity. Fishes examined were 48 mm. in length.

Locality: Lake Waikaremoana.

This species agrees with *G. brevipinnis* in having 7-8 gill-rakers on lower part of anterior arch. It is interesting to note that *G. koaro* has 8 and *G. huttoni* has 9. The body is marked with darker bands. The species is very like *G. attenuatus* and might be directly descended from it. Although comparative measurements vary slightly with age, it is interesting to compare relative lengths of heads in this and other species:—

<i>attenuatus</i>	Length of head 5 to 6½ in the total length.
<i>castleae</i>	Length of head 5.7 to 6 in total length.
<i>brevipinnis</i>	4½ to 5½ as above.
<i>fasciatus</i>	4 to 5 as above.
<i>alepidotus</i>	3½ to 3¾ as above.
<i>huttoni</i>	Nearly 5.
<i>koaro</i>	4.8 to 5.1.

It will be seen that in size of head *castleae* approaches very close to *attenuatus*.

The species is named after Miss Amy Castle, formerly Entomologist, Dominion Museum, in recognition of generous help accorded one of us in identifying insects from stomachs of fish. The Waikaremoana species of *Galaxias* has no previous mention in scientific literature and appears to have escaped the notice of our pioneer ichthyologists, Hector and Hutton.

The *maehe*, as this species is called, is a lake-dwelling species, the young of which are common in Waikaremoana in the summer. The late Elsdon Best informed us that unfortunately nothing is yet on record in regard to the life history of the *maehe*. The species was caught and eaten by the Maoris, and, before the introduction of trout, was an important food fish. It is now not so common as it was fifty years ago.

This fish is known only from Lake Waikaremoana. It is possibly descended from a race of *G. attenuatus* which became land-locked there.

***Galaxias charlottae* sp.nov.** (Plate 21, fig. 2.)

Br. 7 or 8. D?; A.13; P.14; V.1/6; C.14 branched rays. 10 gill-rakers on lower limb of first branchial arch.

Head (40 mm.) 4, depth (36) 4.4, in standard length (161).

Eye (7) 5.6, snout (13) 3, interorbital (18) 2.2, depth of caudal peduncle (24) 1.6 in head.

General form very robust, and deep but strongly compressed posteriorly. Head longer than broad, with the snout tumid and the upper jaw the longer. Maxillary reaching backward nearly to below middle of eye. Teeth minute, none of them canines. A crescentic row of slit-like pores across the chin. A few large pores above eyes, along preorbital, and over preoperculum. The left gill-membrane meets the isthmus slightly in advance of the right gill-membrane. Branchiostegals overlaid by adipose tissue. Nostril somewhat bell-shaped, lying in a depression.

Pectorals and ventrals broadly rounded, more than half length of head. Ventral origin almost halfway between tip of snout and root of caudal. Anal origin behind the vertical of the anterior dorsal rays; when laid back, the anal fin reaches bases of caudal rays. Caudal bilobed, with a fin-like extension above and below the caudal peduncle. Lateral line a median series of simple pores. The fish is covered with thick mucus.

General coloration in formalin, dark brownish grey, fairly uniform, lighter on the belly. A dark blue blotch behind the operculum near the origin of the lateral line. Fins yellowish with blackish margins; in the dorsal, anal, and caudal the membranes are blackish.

Described and figured from the holotype of the species, a specimen 161 mm. in standard length or  $7\frac{1}{2}$  inches in total length.

Austr. Mus. temporarily registered No. 1A. 5195. Preserved in Dominion Museum.

Locality: Queen Charlotte Sound.

Collected by Mr. B. Osborne.

This species is allied to *G. fasciatus* (= *argenteus* Gmelin), but differs in having uniform coloration, a relatively smaller upper jaw, and a deeper habitus. It differs from Regan's description of *G. alepidotus* in dentition and proportions. The correct name of the Mountain Trout or Black Kokopu is *Galaxias argenteus* Gmelin and the Barred Trout or Kokopu is apparently the young, with conspicuous

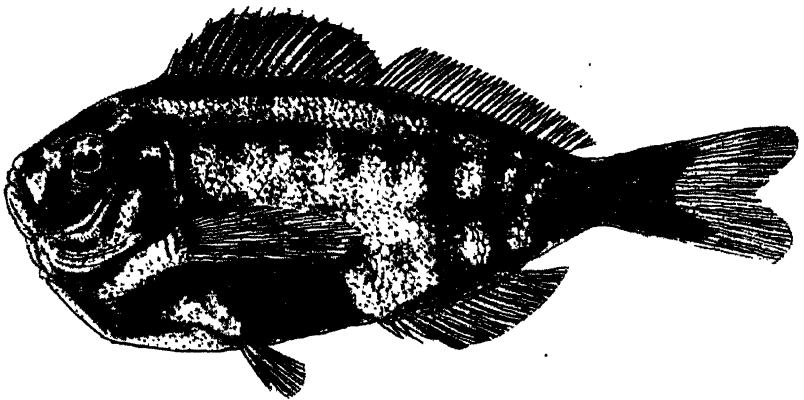
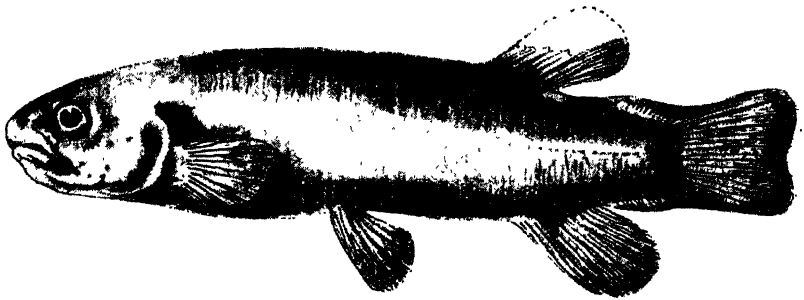
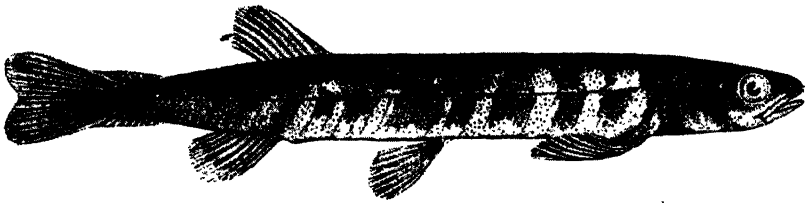


FIG. 1.—*Galaxias castleae* n.sp.

—B. Osborne del.

FIG. 2.—*Galaxias charlottae* n.sp.

—Joyce K. Allan del.

FIG. 3.—*Nemadaetylus concinnus* Richardson.

—Joyce K. Allan del.



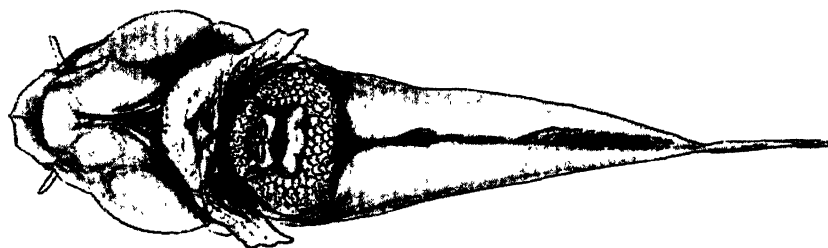
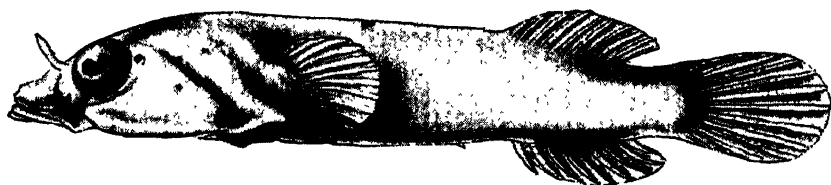
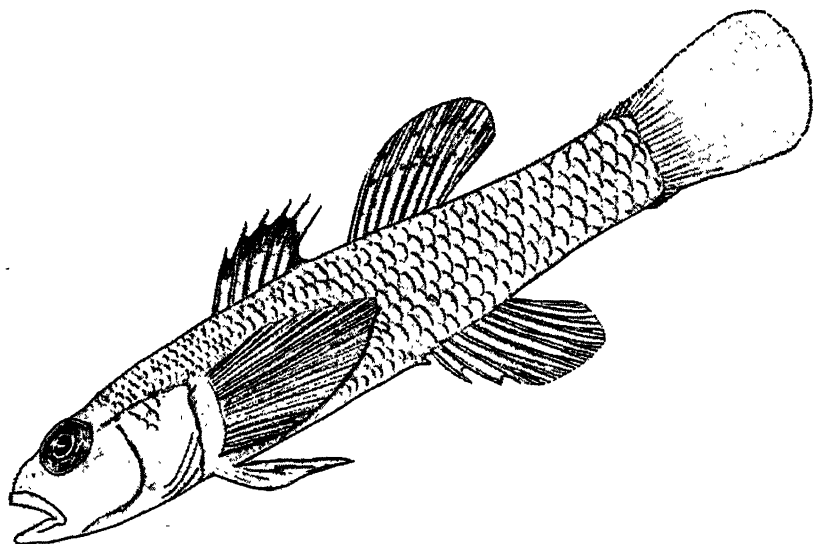


FIG. 4.—*Gobiomorphus huttoni* (Ogilby).

—G. P. Whitley del.

FIG. 5.—*Oliverichtus melobesia* (Phillipps) (side view).

—Joyce K. Allan del.

FIG. 6.—*Oliverichtus melobesia* (Phillipps) (ventral surface).

—Joyce K. Allan del.



markings. The synonymy therefore is: *Galaxias postvectis* Clarke = *G. kokopu* Clarke = *G. grandis* Clarke (preocc. by Haast) = *G. reticulatus* Richardson = *G. broccus* Richardson = *G. forsteri* Cuv. and Val. = *G. fasciatus* Gray = *Esox alepidotus* Bloch and Schneider = *Esox argenteus* Gmelin = *Esox* sp. Forster, *Voy. World Resolut.*, 1, 1777, p. 159, from Dusky Bay.

#### Family BERYCIDAE.

Genus PARATRACHICHTHYS Waite, 1899.

#### *Paratrachichthys trailli* (Hutton).

*Trachichthys trailli* Hutton, *Ann. Mag. Nat. Hist.* (4), 16, Nov., 1875, p. 315, and *Trans. N.Z. Inst.*, 8, May, 1876, p. 212. Stewart Island.

*Trachichthys trailli* Arthur, *Trans. N.Z. Inst.*, 17, 1885, p. 163. pl. 14, fig. 2.

*Id.* Gunther, *Chall. Repts. Zool.*, 22, 1887, p. 23, pl. 55, fig. A.

*Paratrachichthys trailli* (McCulloch), *Zool. Res. Endeavour*, 1, pt. 1, 1911, p. 44.

Through the courtesy of the late H. Hamilton two examples 8 inches and 6½ inches long were acquired by the Dominion Museum some years ago.

The ventral scutes number 13 and 11 respectively. Arthur (1885, *loc. cit.*) found 12 in an example 7½ inches long; so it is possible that the number of these scutes increases as the fish grows.

McCulloch (1911, *loc. cit.*) states that he found from 12 to 16 scutes, and the first either divided or single, with one median and two lateral spines, proving the identity of *T. macleayi* with Hutton's species.

The Roughy or Sand-paper Fish, as the species is called, is not uncommon in trawler catches in New Zealand and southern Australia. An examination of the genital organs showed these were developing in the two above examples taken in Cook Strait in August, while Arthur stated that he found two well-advanced genital lobes in the species which he took in the Otago Harbour in September.

Our examples were for the most part of a brilliant scarlet colour, being more silvery on the ventral surface. The fins were scarlet, with the exception of the ventrals, which were silvery. An excellent description of this fish has been already given by Arthur.

#### Family RHOMBOSOLEIDAE.

Genus RHOMBOSOLEA Gunther, 1862.

Subgenus ADAMASOMA nov.

Genotype, *Rhombosolea retiaria* Hutton.

Sixteen to nineteen gill-rakers on lower part of first branchial arch. Body more or less coloured on blind side, general coloration darker than that of *Rhombosolea*, sensu stricto. Eyes small, about one-seventh length of head. Snout not produced.

#### *Rhombosolea (Adamasoma) retiaria* Hutton.

River or Black Flounder; Patikimohao.

*Rhombosolea retiaria* Hutton, *Trans. N.Z. Inst.*, 6, 1874, p. 107. New name for *R. tapirina* Hutton, *Trans. N.Z. Inst.*, 5, May, 1873, p. 268, pl. 12, fig. 83b, non Gunther. Wellington Harbour.

**Rhombosolea (Adamasoma) retiaria adamas** subsp. nov.

Diamond Plaice.

*Rhombosolea retiaria* Phillipps, *N.Z. Jour. Sci. Tech.*, 7, 6, 1925, p. 368, fig. Hokitika.

This South Island fish is subspecifically distinct from the North Island Black Flounder, the characters of a Hokitika specimen having been given by Phillipps, *loc. cit.*

## Family STROMATEIDAE.

The following genus and species have not yet been defined:—  
*Crystaculeus dyscritus* Thomson, *Ann. Rept. Mar. Dept. N.Z.*, 1926, p. 19. *Nomen nudum ex Young MS.*

## Family NOMEIDAE.

Genus HYPEROGLYPHE Gunther, 1859.

**Hyperoglyphe porosa** (Richardson).*Diagramma porosa* Richardson, *Zool. Voy. Erebus and Terror*, Fish, 1845, p. 26, pl. 16, figs. 5-6. Australia.

It is of interest to place on record the fact that the species figured by Thomson and Anderton under the name *Eurumetopus johnstonii* (*History of the Portobello Marine Fish Hatchery*, 1921, p. 73) is not the above species, but one of the Scorpaenidae, *Helicolenus papillosus* probably.

*H. porosa* appears in Wellington markets at odd intervals. It is sold as bonito and is caught by line fishermen in deep water in Cook Strait. The usual size is 2 ft. 6 in., though much larger examples are recorded. The following is a short description of an example examined on 16th February, 1924:—

The dorsal has seven short spines, the fourth being the longest: second dorsal being 3/17; A.3/11; V.24; pectoral is long and slender, reaching to above anus; ventrals inserted beneath the pectoral a little further back, and reaching halfway from its base to anus. The lateral line contains about 90 scales and curves above pectoral; maxillary reaches to under posterior of eye; caudal deeply concave; diameter of eye 1.75 inches; length of head 8 inches; depth of ventral base 8.75 inches, length of pectoral 7.75 inches, total length 2 ft. 6½ in.

## Family CEPOLIDAE.

Genus CEPOLA Linné, 1764.

**Cepola aotea** Waite.*Cepola aotea* Waite, *Proc. N.Z. Inst.*, 1910, pt. 1, Sept. 10, 1910, p. 26. Bay of Plenty, New Zealand.

At the end of August, 1931, some collegè boys found a fish on Wanganui Beach which has been identified with the above species.

Mr G. Shepherd kindly supplies the following description:—

Length from snout to hypural joint 45 cm.; greatest depth 28 mm.; depth of hypural joint 3mm.; point of snout to vent 73 mm.; teeth in upper jaw, 4 anterior on either side, large and hooked, the anterior pair the longest, widely spaced, behind a row of closely set small teeth, lower jaw has 6 large

widely spaced hooked teeth on either side anteriorly and behind a closely set row of smaller teeth; all teeth in a single series; premaxillary extends to base of maxillary which is much dilated and square at base. Colour is uniform bright red including anal fin and eye, ventrals whitish. The whole fish is extremely slender, greatly compressed, and tapered almost to a point.

D.72; A.66; V.1 + 5; Br.5.

Gill-rakers numerous and comb-like.

*Hypolycodes haastii* resembles this species; but has a larger number of dorsal fin rays.

#### Family HISTIOPTERIDAE.

##### Genus GRIFFINETTA nov.

Genotype, *Griffinetta nelsonensis* sp.nov.

Fourteen dorsal spines and four anal spines. Base of soft dorsal much shorter than that of the spinous dorsal, none of the fins falcate. Head and scapular regions with exposed, rugose, bony surfaces radially striated. A few small teeth form a band in each jaw, and others are present on the vomer, but the palatines are edentulous. Snout not excavate or produced.

Named after the late Louis T. Griffin of Auckland.

##### *Griffinetta nelsonensis* sp.nov.

*Pseudopentaceros richardsoni* McCulloch and Phillipps, *Rec. Austr. Mus.*, 14, 1, Feb. 28, 1923, p. 18, pl. 4, fig. 1. Nelson, New Zealand. Not *Pentaceros richardsoni* Smith, *Illustrations of the Zoology of South Africa, Pisces*, 1844, pl. 21, from South Africa.

#### Family CHEILODACTYLIDAE.

We consider that records of the Chilean *Mendosoma lineatum* Guichenot (Gay's *Chili, Peces*, 1849, p. 213, pl. 5, fig. 2) from New Zealand, actually refer to young specimens of the Trumpeter, *Latris lineata* (Bloch and Schneider).

##### Genus NEMADACTYLUS Richardson, 1839.

*Nemadactylus* Richardson, *Proc. Zool. Soc. London*, 7, Nov., 1839, p. 97. Orthotype, *N. concinnus* Richardson.

*Nematodactylus* Gill, *Proc. Acad. Nat. Sci. Philad.*, 1862, pp. 114 and 121. *Id.* Boulenger, *Zool. Record*, 1880 (1881), *Pisces*, p. 8. Emendations.

This genus may perhaps be founded on some incompletely developed Cheilodactylid, but is evidently not the young of any well-known species, such as the Terakihi (*Sciaenoides macropterus*), since its fin-formulae are so different. The relationships of *Nemadactylus* have always been a puzzle and until now it has only been known from around Tasmania and the Island of St. Paul. We are now able to record it from New Zealand on the basis of the interesting little specimen described below.

**Nemadactylus concinnus** Richardson. (Plate 21, fig. 3.)

*Nemadactylus concinnus* Richardson, *Proc. Zool. Soc. Lond.*, 7, Nov., 1839, p. 97; *Trans. Zool. Soc. Lond.*, 3, June 16, 1842, p. 116, pl. 4, fig. 2; *Rept. Brit. Assn. Adv. Sci.*, 11, 1841 (1842), p. 71; *Tasm. Journ. Sci.*, 1, 1842, p. 63. *Id.* Gunther, *Cat. Fish. Brit. Mus.*, 2, 1860, p. 85 (? and p. 415 as *Mene maculata* from "Open sea"). *Id.* Kner, *Sitzungsber. Akad. Wiss. Wien*, 49, 1, 1864, p. 486 (no loc.); *Reise Novara, Zool.*, 1865, p. 94. *Id.* Sauvage, *Comptes Rendus*, 81, 1875, p. 988 (St. Paul) and *Arch. Zool. Exper.*, 8, 1879, pp. 3 and 22. *Id.* Johnston, *Proc. Roy. Soc. Tasm.*, 1882 (1883), p. 113 et *ibid.* 1890 (1891), p. 31. *Id.* McCulloch, *Austr. Mus. Mem.* 5, 2, 1929, p. 257.

? *Platystethus huttonii* Gunther, *Rept. Voy. Challenger, Zool.*, 31, 78, 1889, p. 13. Part only, not type, but young specimens nos. 1 and 2 from between Australia and New Zealand and between Australia and South Africa. Not *Platystethus huttonii* Gunther, *Ann. Mag. Nat. Hist.* (4), 17, 1876, pp. 390 and 395, a species of *Eristius*.

D.18/28; A.3/16; P.15; V.1/5 C.13 branched rays. L.lat.55.

Head  $3\frac{1}{2}$ , height of body  $2\frac{1}{2}$  in standard length. Eye nearly  $3\frac{1}{2}$  in head. First dorsal fin commences very slightly in advance of the vertical of opercular edge. Anal commences below second dorsal's origin. Pectoral commences below first dorsal and reaches to origin of second. Anal ceases below a point about two-thirds of the way along the second dorsal. Total length 78 mm. Snout to first dorsal 14. Diameter of eye 5. Eye to end of snout 4. Depth at dorsal origin 24. Snout to anal origin 35. Length of caudal 16. Longest ray of pectoral 16. Length of head 16.

The angle of the mouth reaches over half the distance from the snout to the eye and inclines obliquely downward at about  $45^\circ$  to the horizontal line of the body. The suboperculum is striated and the eyes and front of the head are covered by a transparent membrane.

Described and figured from a specimen 78 mm. long or about three inches overall. Temporarily registered No. 1A. 5196, Austr. Mus. Now preserved in the Dominion Museum.

Locality: Mouth of the Waikanae River, New Zealand; 17th November, 1930. Collected by Captain Hayes.

Relationships: This is evidently a pelagic species referable to the Cheilodactylidae, yet in some respects it recalls *Eristius* and *Platystethus*. Barnard, in South Africa, has identified some of Gunther's "Challenger" specimens of "*Platystethus huttonii*" as young Cheilodactylidae, near, if not identical with, the genus *Palunolepis* Barnard, 1927. Again, on comparing descriptions and figures of fishes identified by authors as *Eristius huttonii*, discrepancies in formulae and proportions are noticeable, and it is evident that more than one species has been confused. We think we are correct in identifying our New Zealand specimen as *N. concinnus*, because it agrees well with Richardson's detailed description and figure published in 1842; the only differences are the deeper thoracic profile and the smaller size, but these might be accounted for by growth-changes.

In our detailed analysis of descriptions and records of *Nemadactylus*, *Eristius*, and *Platystethus*, one fact emerges: the Tasmanian form of *Eristius huttonii* recorded by McCulloch (*Rec. Austr. Mus.*, 14, 2, 1923, p. 121) actually represents a new subspecies, which we name *Eristius huttonii tasmaniensis*. n.subsp.

## Family PARAPERCICHTHYIDAE nov.

## Genus PARAPERCICHTHYS nov.

Genotype, *Enchelyopus colias* Bloch and Schneider (*Syst. Ichth.*, 1801, p. 54.

Type-loc. Queen Charlotte Sound, South Island, New Zealand).

This is the New Zealand Blue Cod which has been erroneously placed in the genera *Percis* or *Parapercis* by modern authors. It has, however, no affinity whatever with the typical members of those genera, so the above slight nomenclatural change is made and the species may henceforth be called *Parapercichthys colias*.

The genotype of *Parapercis* is *cylindrica*, a relatively large scaled species with 50 scales in the lateral line, while *colias* has 66. Vomerine and palatine teeth present in *cylindrica* are absent from *colias*.

*Percis gilliesii* Hutton (*Ann. Mag. Nat. Hist.* (5), 3, Jan. 1, 1879, p. 53) from Brighton, near Dunedin, belongs to the genus *Neopercis* Steindachner, in the family Parapercidae.

## Family URANOSCOPIIDAE.

## Genus GNATHAGNOIDES nov.

Genotype, *Gnathagnus innotabilis* Waite (*Rec. Austr. Mus.*, 5, 4, June 16, 1904, p. 238, pl. 26, fig. 1), from New South Wales.

This new genus is allied to the Japanese *Gnathagnus* Gill, 1861, whose genotype is *Uranoscopus elongatus* Temminck and Schlegel, but differs from the latter in having a pronounced humeral spine, rounded plectroid mental dilatations, differently formed fins, and apparently different skull-structure.

The New Zealand form is larger in size than the Australian, and may be named *Gnathagnoides innotabilis grandior* subsp. nov.

## Family ELEOTRIDAE.

## Genus GOBIOMORPHUS Gill, 1863.

**Gobiomorphus huttoni** (Ogilby). (Plate 22, fig. 4.)

"*Gobius* n.sp." Krefft *List Rept. Fish Austr. Mus.*, 1862, p. 13.

*Eleotris huttoni* Ogilby, *Proc. Linn. Soc. N.S. Wales* (2), 9, 1894, p. 369.

Waikato River, North Island of New Zealand.

This species was excellently described by Ogilby, but has not been featured in New Zealand ichthyological literature.

The holotype, here figured for the first time, is an old specimen (regd. no. 1. 3162) in the Australian Museum, Sydney.

The species appears to be valid, being distinguished from *Gobiomorphus gobioides* (Cuvier and Valenciennes) by having less extensive jaws, a narrowed interorbital, comparatively smaller scales and fewer dorsal rays.

## Family BLENNIIDAE.

## Genus GILLOBLENNIUS nov.

Genotype, *Blennius tripennis* Bloch and Schneider, *Syst. Ichth.*, 1801, p. 174. *Eo* Forster MS. South Island, New Zealand. Now *Gilloblennius tripennis*.

This genus is distinguished by the very long lateral line, which is more primitive in structure than in other New Zealand blennies, in which it has atrophied. Dorsal spines three. Head pointed, its

profile much less steep than in other Three-fin Blennies. Other characters as given by Waite, *Rec. Canterb. Mus.*, 2, 1913, p. 3.

Genus FORSTERYGION nov.

Genotype, *Blennius varius* Bloch and Schneider, *Syst. Ichth.*, 1801, p. 178. *Ex* Forster MS. South Island of New Zealand.

Cuvier and Valenciennes (*Hist. Nat. Poiss.*, 11, July, 1836, p. 413, pl. 339) figure this New Zealand blenny as *Tripterygion nigripenne* beside the typical *Tripterygion (naso)*. Though both forms have since been retained in *Tripterygion*, they should be separated generically, since the New Zealand species differs in being of much larger size, has an increased number of dorsal spines, and a quite differently shaped head. The lateral line of Wellington specimens which we have examined ends sometimes below the second and sometimes below the third dorsal fin.

It may be mentioned here that *Enneapterygius mortenseni* Rendahl, 1925, is evidently a synonym of *Helcogramma medium* (Gunther), originally described in 1861 as another *Tripterygium*.

Family LINOPHRYNIDAE.

Genus HAPLOPHRYNE Regan, 1912.

*Haplophryne triregium* sp. nov.

New name for *Haplophryne mollis* of Regan (*Terra Nova, Zool.*, 1, 4, March 25, 1916, p. 148, pl. 10, fig. 2) from surface at Three Kings Islands, not *Aceratias mollis* Brauer (*Zool. Anzeiger*, 25, April 7, 1902, p. 297) from the "Mitte des Indischen Oceans, Tiefe 2200 m." This type-locality was between New Amsterdam and Cocos Island, *vide* Brauer, *Wissen. Ergebn. Deutschen Tiefsee-Exped. Valdivia*, 1906, p. 324, pl. 16, fig. 10.

Brauer's specimen is larger than Regan's, and the New Zealand fish differs in having much smaller nostrils, a different bodily outline, anal origin in advance of that of dorsal, and a hidden rudimentary illicium, the pectoral fin is differently situated and there are spot-like chromatophores on the flanks.

Family GOBIESOCIDAE.

Genus OLIVERICHTUS nov.

Genotype, *Oliverichtus melobesia* (Phillipps, 1927). Plate 22, figs. 5 and 6.

A species, *Trachelochismus melobesia*, was described by Phillipps, *Trans. N.Z. Inst.*, 58, p. 131, pl. 5. Numerous specimens had been collected by Dr. W. R. B. Oliver under rocks in beach pools on the westerly coasts of Wellington. Its differences from *Trachelochismus* were realised at the time. The dorsal and anal are much larger and the number of ventral rays smaller than in *Trachelochismus*. We therefore designate *Trachelochismus melobesia* Phillipps as the genotype of *Oliverichtus* gen. nov. The body is held to the rocks by a disc quite unlike that of related genera. The following additional material on this interesting species may now be added:—Length of head 9 mm., interorbital space 2 mm., eye 1 mm., eye to snout 1.8 mm., total length 28 mm., length to caudal peduncle 24 mm., coralline patch 12 x 7 mm., sucker 4 mm., height of body 3 mm. D.9; P.10; C.10; A.9; V.3 fused rays.

## The Mould Fungi of New Zealand.

### II. THE GENUS *ASPERGILLUS*.

By J. C. NEILL, Plant Diseases Division, Plant Research Bureau, Auckland.

[Read before the Manawatu Branch, September 21, 1938; received by the Editor, December 22, 1938; issued separately, September, 1939.]

FUNGI belonging to the genus *Aspergillus* constitute, with the closely related genus *Penicillium*, the common spoilage moulds of foodstuffs, textiles and leather the world over. Several of them are pathogenic to plants and animals, including man. Others are used in industry—notably in the manufacture of citric acid and in the preparation of fermented food and drink. Of the multitude of articles published by botanists, pathologists, and chemists touching the *Aspergilli*, comparatively few deal with the botanical classification of the genus. The monograph by Thom and Church (*The Aspergilli*, 1926) is the only comprehensive work of this character published within recent years. In it the authors review the world's literature on the genus, supplemented by personal examination of a wide range of specimens and of type cultures. They define, in general terms, groups composed of related species, but rarely lay down definite lines of demarcation between the species comprising each group. While the inquirer can, with reasonable precision, place his specimen within a group he is left in some doubt as to the choice of a specific name.

In attempting to record the New Zealand *Aspergilli* it has been found necessary to lay down clear boundary lines between species, based on definite morphological characters. This has entailed a review of the systematics of the whole genus and the relegation to synonymy of all but 18 of the 66 specific names accepted by Thom and Church out of the 400 or so in existence.

The strains recorded here have been isolated in the course of industrial and soil mycological work over the past four years. They do not purport to form a complete list of the *Aspergilli* present in New Zealand.

Genus *ASPERGILLUS* Micheli, emend. Corda.

*Icon. Fung.*, II, p. 18, 1838.

*Sterigmatocystis* Cramer, *Viert. Nat. Gesell.*, vol. 4, p. 325, 1859.

*Aspergillopsis* Spegazzini, *An. Mus. Nac. Buenos Aires*, Ser. III, vol. 13, p. 434, 1911.

*Diplostephanus* Langeron, *Compt. Rend. Soc. Biol.*, France, vol. 87, p. 343, 1922.

Sterile hyphae creeping, septate, hyaline, sometimes in age tinged yellow or brown. Fertile hyphae (stalk) erect, normally unbranched, thick walled, budding from side-wall of a hyphal cell which often becomes thick walled, swollen and distorted (foot-cell), very sparsely septate, with apex swollen to form a globose, flask-shaped, or more or less clavate vesicle. Sterigmata arising as buds from the vesicle wall, either bearing conidia directly (1 series), or budding at apex 1 to 5 secondary sterigmata which bear the conidia (2 series). Conidial sterigmata cylindrical or vase-shaped, narrowing more or less abruptly at apex to form an apical tube within which the conidia arise in succession. Conidia continuous, elliptical or globose, hyaline or with outer wall coloured green, yellow, or brown, in unbranched chains

radiating to form a mop-like or globose head, or more or less compacted to form stellate masses or cylindrical columns, not enveloped in slime.

Perithecia, when present, globose or oval, cleistocarpic, thin-walled. Asci globose, containing 8 spores. Ascospores more or less lens-shaped, with or without median groove and projecting membranes.

Sclerotia, when present, more or less spherical, composed of compacted masses of globose cells with lumen nearly filled with horny material.

There appears to be no clear line of division between the genera *Aspergillus* and *Penicillium*. *P. spinulosum* might well pass for a small columnar *Aspergillus*, its numerous sterigmata being borne on an apical vesicle more than twice the diameter of the stalk. The swollen and contorted "foot cell" at the base of the stalk, though prominent in the larger forms, is less easily observed in degenerate cultures or in small stalked species such as *A. fumigatus*, nor is it present at the foot of stalks that arise from aerial hyphae. Certain *Penicillia* also exhibit definite footcells. Pure cultures of *Aspergilli*, when becoming degenerate through age, staling, unsuitable media, or bacterial contamination, often produce typically penicillate fructifications. The general morphology of the essential organs of propagation, sterigmata and conidia, varies more between the species of each genus than between the two genera as a whole.

However, the generally accepted conception of the two genera is sufficiently distinct to obviate the necessity for altering such well-established names.

Border-line species can well be placed in one or the other.

#### THE SPECIES OF *Aspergillus*.

In attempting to key and define the species of the genus it is imperative that characters are used that are constant, within specified limits, under all conditions of growth, and that are precisely definable in words. To be of value such a key must allow a worker unfamiliar with the group to name a specimen in hand rapidly and with confidence, independent of the medium on which it occurs. It is, of course, not possible to lay down rigid boundary lines between such variable and closely related organisms, but the key characters should be so chosen that border-line strains may be placed with the least doubt. Defined thus the species name must inevitably cover a number of strains variable in other than the key characters.

#### Colour.

#### DISCUSSION OF KEY CHARACTERS.

This is taken to apply to the conidial heads in mass. The exact shade is too variable a character for use in the separation of closely-related species, but, in the generalized form of blue-green, green, yellow-green, yellow-brown, flesh-colour, white or black, constitutes a convenient and immediately apparent character for separation of the species into major groups. It has been so used by most workers on the genus.

#### Morphology.

The organs available for morphological comparison are the vegetative mycelium, stalk, foot-cell, vesicle, sterigmata, conidia, sclerotia, and perithecia.

*Vegetation mycelium.* Careful observations have failed to find any constant distinguishing character in either the submerged or aerial mycelium of different species. The various coloured inclusions and accretions, and the swellings and abnormalities of the submerged hyphae, that are sometimes present, as well as the relative abundance of aerial hyphae, to some extent characteristic of certain strains and species, are, in general, variables associated with age and vigour.

*Stalk.* Measurements of length, diameter, and thickness of wall provide useful descriptive data, but are not suitable for use as key characters. Smoothness of outer wall as contrasted with walls bearing wart-like accretions, usually washed off in mounting, but leaving scars or pits, forms a readily observed and useful key character. Stalk colour is apparently a constant character for some species and for them constitutes a key character.

*Foot-cell.* Shape and dimensions of the foot-cell vary greatly between individual stalks in any one colony and therefore have no diagnostic value as between species.

*Vesicle.* The shape of the vesicle is of value in separating *A. clavatus* from other *Aspergilli*, but otherwise variations cannot be defined with sufficient precision. The manner in which the sterigmata are borne upon the vesicle is of indirect value in that it indicates whether the heads are normally columnar or radiate—a key character usually observed directly on the growing colony.

*Sterigmata.* Whether the sterigmata are unbranched (1 series) or branched (2 series) constitutes a key character that must be used with discretion. Age and conditions of culture may influence the branching of the sterigmata and some species may have both branched and unbranched sterigmata in the same colony. Other species, however, are constant in producing their sterigmata in either 1 or 2 series and with these the distinction is valid.

The relative morphology of the sterigmata is of some diagnostic value, but the distinctions are difficult to define succinctly.

*Conidia.* Conidial morphology has been used in the present key as a character for separation of certain species only. The conidia of some species vary in shape and size, and in markings of the epispore, between strain and strain and even under different conditions of culture. All three characters, however, are valuable confirmatory aids to diagnosis and are detailed in each species description. Colour in the mass and the manner in which the conidial chains are borne on the undisturbed head, whether radiate or compacted into solid columns, are characters of the utmost value for key divisions.

*Sclerotia.* Formation of "Hülle" cells\* and of sclerotia, though apparently a property of certain species only, is governed largely by environmental conditions and therefore cannot be considered a key character.

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\* "Hülle cells" are special cells, usually terminal to aerial vegetative hyphae, in which the walls are so thickened as nearly to obliterate the lumen. They are particularly well observed in the hyphal web surrounding the perithecia of *A. nidulans*.

*Perithecia.*

Perithecia are at present known for only a very few species of *Aspergilli*. Strictly such species should be classed under the ascomycetous genus *Eurotium*, but, in agreement with most workers, they are here retained under *Aspergillus*.

*Cultural Characters.*

These vary so widely between strain and strain, and under varying conditions, that they have little or no value for key purposes. As aids to diagnosis they have at times some value and as such are given for each species grown on a standardized medium, Czapek's solution agar ex Thom and Church:— $\text{NaNO}_3$  2 grms.,  $\text{K}_2\text{HPO}_4$  1 grm.,  $\text{MgSO}_4$  0.5 grm.,  $\text{KCl}$  0.5 grm.,  $\text{FeSO}_4$  trace, Sucrose 30 grms., water 1 litre, Agar 15 grms. The addition of 10 grms. of "Marmite" to the above formula greatly improves colony vigour without affecting other characters.

## KEY TO SPECIES.

Heads blue-green.				
Vesicles clavate.	..	..	..	<i>A. clavatus</i> 1
Vesicles flask-shaped.				
Sterigmata in 1 series.	..	..	..	<i>A. fumigatus</i> 2
Sterigmata in 2 series	..	..	..	<i>A. nidulans</i> 3
Heads green.				
Heads columnar.	..	..	..	<i>A. caesiellus</i> 4
Heads radiate.				
Sterigmata in 1 series.	..	..	..	<i>A. glaucus</i> <sup>(1)</sup> 5
Sterigmata in 2 series.	..	..	..	<i>A. versicolor</i> <sup>(2)</sup> 6
Heads yellow-green.	..	..	..	<i>A. flavus</i> 7
Heads yellow to brown.				
Stalks smooth.				
Heads hemispherical to columnar.	..	..	..	( <i>A. ustus</i> ) <sup>(3)</sup> 8
Heads globose.				
Conidia rough, over 4 $\mu$ .	..	..	..	<i>A. wentii</i> 9
Conidia smooth, 3 $\mu$ .	..	..	..	( <i>A. alliaceus</i> ) 10
Stalks rough.				
Conidia pyriform to globose.				
Stalks yellow.	..	..	..	( <i>A. ochraceus</i> ) 11
Stalks colourless.	..	..	..	( <i>A. tamarisii</i> ) 12
Conidia lemon-shaped.	..	..	..	( <i>A. citrisporus</i> ) 13
Heads flesh-coloured.				
Heads columnar	..	..	..	<i>A. terreus</i> 14
Heads radiate.	..	..	..	<i>A. cervinus</i> 15
Heads white.				
Stalks yellow.	..	..	..	( <i>A. flavipes</i> ) 16
Stalks colourless.	..	..	..	<i>A. candidus</i> 17
Heads black.				
				<i>A. niger</i> 18

(1) Cultures of *A. glaucus* often exhibit yellow and red shades due to colour of the vegetative hyphae and perithecia.

(2) Some strains of *A. versicolor* exhibit variations in colour ranging from blue-green, green, yellow-green to buff.

(3) Brackets indicate species not yet found in New Zealand.

1. *A. clavatus* Desmazières, *Ann. Sci. Nat. Bot.*, Ser. II, vol. 2, p. 71, 1834.

*A. clavellus* Peck, *New York St. Mus. Nat. Hist. Rept.* 34, p. 49, 1881.

*A. giganteus* Wehmer, *Centralb. Bakt.*, II, vol. 18, p. 385, 1907.

Heads at first blue-green, becoming dark green in age, clavate, with pseudo-columnar appearance when young, with jagged outline due to irregular massing of conidial chains in age. Stalks smooth, hyaline, 0.6–3 mm.  $\times$  15–40  $\mu$ , walls 0.5–1.5  $\mu$  thick. Vesicles clavate, fertile over an area up to 150  $\mu$  long by 20–40  $\mu$  diameter. Sterigmata 1 series, closely set, with axis approximately perpendicular to vesicle, 7–12  $\mu$   $\times$  2.5–4  $\mu$ , narrowing abruptly to short apical tube. Conidia smooth, elliptical, 4–4.5  $\mu$   $\times$  3–3.5  $\mu$ . No perithecia or sclerotia observed.

Czapek colony vigorous, floccose, soon covered with close-set blue-green heads. Reverse tinged yellow to brown.

Habitat: Malt, oatmeal, "Puffed Wheat," soil. (5 isolants.)

2. *A. fumigatus* Fresenius, *Beitr. z. Mykol.*, p. 81, 1853.

*A. malignus* Lindt., *Arch. Exp. Path. Phar.*, vol. 25, p. 257, 1889.

*A. aviarius* Peck, *New York St. Mus. Rept.* (1890), 44, p. 120, 1892.

*A. penicilloides* Speg., *Rev. Agrar. Vet. La Plata*, p. 246, 1896.

*A. bronchialis* Blumentr., *Ber. Deut. Bot. Ges.*, vol. 19, p. 442, 1901.

*A. syncephalis* Gueguen, *Champ. Parasit. Hom. Anim.*, p. 165, 1904.

*S. pseudo-nidulans* Vuill., *Arch. Parasit.*, vol. 8, p. 540, 1904.

*A. lignieresii* Cost. and Lucet, *Ann. Sci. Nat. Bot.*, IX, vol. 2, p. 137, 1905.

*A. virido-griseus* Cost. and Lucet, *l.c.*, p. 140, 1905.

*A. fumigatus* var. *tumescens* Blumentr., *Ber. Deut. Bot. Ges.*, vol. 23, p. 419, 1905.

*A. fischeri* Wehmer, *Centralb. Bakt.*, II, vol. 18, p. 390, 1907.

*A. fumigatus* var. *alpha* Sion and Alex., *Compt. Rend. Soc. Biol.*, vol. 64, p. 288, 1908.

*A. fumigatoides* Bain. and Sart., *Bul. Soc. Myc. France*, vol. 25, p. 112, 1909.

*A. fumigatus* var. *minimus* Sart., *Bul. Acad. Med.*, Ser. III, vol. 82, p. 304, 1919.

*A. cellulosa* Hopfe, *Centralb. Bakt.*, I, vol. 83, p. 531, 1919.

Heads bright blue-green, later darkening to dull brownish-green, compactly or loosely columnar, 100  $\mu$ –300  $\mu$   $\times$  30–70  $\mu$ . Stalks smooth, usually tinged green towards apex, 100–300  $\mu$   $\times$  4–8  $\mu$ , enlarging upwards. Vesicles flask-shaped 20–30  $\mu$   $\times$  15–20  $\mu$ , fertile on apical half only or on nearly the whole surface. Sterigmata 1 series, closely set, apices mostly directed upwards, 5–8  $\mu$   $\times$  2.5–3  $\mu$ , narrowing abruptly to short apical tube. Conidia smooth or roughened, globose or slightly elliptical, 2.3–3.3  $\mu$  in longest diameter. Perithecia formed by one strain, flesh coloured, more or less globose, 180–240  $\mu$  in diameter. Asci globose 11–12  $\mu$ . Ascospores 5  $\mu$  wide, 4  $\mu$  deep, with groove and double membrane 1  $\mu$  wide. Sclerotia not observed, but isolated groups of Hülle cells present in two strains.

Czapek colony spreading, at first floccose, later velutinous with isolated tufts of aerial hyphae, at first blue-green, later dull brownish-green. Reverse tinged greenish-yellow.

Habitat: Sclerotium of *Claviceps purpurea*, daffodil bulb, shoe leather, scrapings from ear of hospital patient. (5 isolants.)

3. *A. nidulans* (Eidam) Winter, *Rabh. Krypt. Fl.*, vol. 2, p. 65, 1887.

*S. nidulans* Eidam, Cohn's *Beitr. Biol. Pfl.*, vol. 3, p. 392, 1883.

*S. nidulans* var. *nicolletii* Pinoy, *Arch. Parasit.*, vol. 10, p. 437, 1908.

*S. nidulans* forme *cesarii* Pinoy, *Bull. Soc. Path. Exot.*, vol. 8, p. 11, 1915.

*Diplostephanus nidulans* (Eidam) Langeron, *Compt. Rend. Soc. Biol.*, vol. 87, p. 343, 1922.

*A. amoenus* Roberg, *Hedwigia*, vol. 70, p. 138, 1930.

Heads blue-green, becoming glaucous-green, semi-radiate when young, becoming loosely or compactly columnar in age, 90–150  $\mu$  long by up to 60  $\mu$  in diameter. Stalks smooth, generally flexuous, enlarging upwards, tinted brown, 40–80  $\mu \times 4\text{--}5\ \mu$ . Vesicles flask-shaped, 10–15  $\mu$  diameter, fertile on upper surface only. Sterigmata in 2 series, primary 4–6  $\mu \times 3\ \mu$ , secondary 6–9  $\mu \times 2\text{--}2.5\ \mu$ , with blunt apex and short very narrow apical tube, up to 5 per primary, axes of lower series bent upwards. Conidia globose, coarsely verrucose, 2.5–3.3  $\mu$  diam. in one strain, delicately roughened 3–3.5  $\mu$  in another. Perithecia embedded in web of interlacing hyphae that terminate in globose thick-walled Hülle cells about 20  $\mu$  diameter, subglobose, to 300  $\mu$  diameter. Asci globose 9–10  $\mu$  diameter, ephemeral, containing 8 spores. Ascospores purple, smooth, in one strain 4.5  $\mu \times 3.8\ \mu$  with double equatorial membrane 1.25  $\mu$  wide, in the other strain 4.5  $\mu \times 3.5\ \mu$  with double equatorial membrane 0.5  $\mu$  wide. In this latter strain the membranes are very close together, appearing as a single thick membrane unless clearly defined. Asci ripen only after several weeks in culture.

Czapek colony vigorous floccose soon becoming velutinous, blue-green finally dark green. Reverse tinged pink to deep maroon, staining media.

Habitat: Macaroni, crushed maize. (2 isolants.)

4. *A. caesiellus* Saito, *Jour. Coll. Sci. Imp. Univ. Tokyo*, vol. 18, art. 5, p. 49, 1904.

*A. gracilis* Bain., *Bul. Soc. Myc. France*, vol. 23, p. 92, 1907.

*A. cinereosens* Bain. and Sart., *Bul. Soc. Myc. France*, vol. 27, p. 98, 1911.

*A. conicus* Blwz. ex Dale, *Ann. Myc.*, vol. 12, p. 38, 1914.

*A. restrictus* Smith, *Jour. Tent. Inst.*, vol. 22, p. T 115, 1931.

*A. restrictus* var. *B.* Smith, *l.c.*

Heads dark green, columnar, to 300  $\mu \times 40\ \mu$ , showing basal half of vesicle. Stalks smooth, hyaline, often sinuous, 50–100  $\mu \times 5\text{--}6\ \mu$ , walls 0.5  $\mu$  thick, arising from submerged and aerial hyphae and hyphal ropes. Vesicles globose to flask-shaped, 10–15  $\mu$  diameter, fertile only on apical dome. Sterigmata 1 series, closely packed, axes parallel with stalk, 9–10  $\mu \times 3.5\ \mu$ , narrowing abruptly to short apical tube. Conidia very rough, elliptical, 6–9  $\mu \times 3.5\text{--}4\ \mu$ , forming a solid cylindrical column. The young conidia are slow to abstrict in the chain, remaining attached in mounts, and, when detached, appearing barrel-shaped with flattened ends. No perithecia or sclerotia observed.

Czapek colony restricted, with greyish floccose aerial hyphae, dull green to deep green, darkening in age. Reverse dark green to black.

Habitat: Air in hospital, rolled oats, oatmeal. (3 isolants.)

The "slime" condition described for "*A. conicus*" by Dale and by Thom and Church (*The Asperg.*, p. 125, 1926) was present in the colony which developed on an air-exposed plate of "Difco" prune agar. Subcultures direct to Czapek and potato-dextrose agars were also slimy. A similar condition had been noted in old stock cultures of *A. glaucus*. No bacteria could be found in direct examination or in dilution cultures on various media, nor could the condition be produced in non-slimy colonies by direct inoculation. It was found, however, that transfers of mass inoculum to "Difco" prune agar plus 40% cane sugar produced colonies apparently healthy and free from slime.

The "slime" condition is associated with other evidences of degeneration—contorted hyphae, lack of vigour, irregularity in fruiting, darkening of colour in the submerged hyphae and in the media, etc. The conidia remain normal. The two strains isolated from oats did not show the "slime" condition. It appears therefore, that the condition is of physiological origin and is not a constant species character—an opinion also held by Blochwitz (*Ann. Myc.*, vol. 23, p. 206, 1929).

5. *A. glaucus* Link, *Mag. Ges. Nat. Fr. Berlin*, vol. 3, p. 16, 1809.

*A. glaucus* var. *repens* Corda, *Icon. Fung.*, vol. 5, p. 53, 1842.

*A. glaucus* var. *olivaceus* Sacc., *Michelia*, vol. 2, p. 543, 1878.

*A. repens* (Corda) Sacc., *Syll. Fung.*, vol. 4, p. 64, 1886.

*A. herbariorum* (Wigg.) Wint., *Rabh. Krypt. Fl.*, vol. 2, p. 59, 1887.

*A. brunneus* Delacr., *Bul. Soc. Myc.*, vol. 9, p. 185, 1893.

*A. medius* Meissn., *Bot. Ztg.*, II, vol. 55, p. 337, 1897.

*A. tokelau* Wehmer, *Centralb. Bakt.*, I, vol. 35, p. 140, 1903.

*A. fontoyonti* Gueguen, *Arch. Parasit.*, vol. 14, p. 177, 1910.

*A. glaucus* var. *minimus* Hanzawa, *Jour. Coll. Agr. Imp. Univ. Sapporo*, vol. 4, p. 220, 1911.

*A. disjunctus* Bain. and Sart., *Bull. Soc. Myc. France*, vol. 27, p. 346, 1911.

*A. sejunctus* Bain. and Sart., *l.c.*, p. 346, 1911.

*A. mollis* Bain. and Sart., *l.c.*, p. 453, 1911.

*A. mutabilis* Bain. and Sart., *l.c.*, p. 458, 1911.

*A. repandus* Bain. and Sart., *l.c.*, p. 463, 1911.

*A. scheelei* Bain. and Sart., *ibid.*, vol. 28, p. 257, 1912.

*A. umbrosus* Bain. and Sart., *l.c.*, p. 267, 1912.

*A. maydis* Quevedo, *De Agronomia*, vol. 8, 1912.

*A. sartoryi* Syd., *Ann. Myc.*, vol. 11, p. 156, 1913.

*A. glaucus* var. *subolivaceus* Ferraris, *Fl. Ital. Crypt. Pars.*, I, Fas. 13, p. 911, 1914.

*A. brunneo-fuscus* See, *Malad. Pap. Piqué*, p. 29, 1919.

*A. menciari* Sart. and Flam., *Champ. Parasit. Hom. Anim.*, p. 578, 1922.

*A. herbariorum* ser. *major* var. *violaceus* (Mangin) Th. and Ch., *The Asperg.*, p. 102, 1926.

*A. echinulatus* (Delacr.) Th. and Ch., *l.c.*, p. 107, 1926.

*A. chevalieri* (Mangin) Th. and Ch., *l.c.*, p. 111, 1926.

*A. ruber* (Sp. and Br.) Th. and Ch., *l.c.*, p. 112, 1926.

*A. amstelodami* (Mangin) Th. and Ch., *l.c.*, p. 113, 1926.

*A. pseudoglaucus* Blvz., *Ann. Myc.*, vol. 27, p. 207.

*A. aureoglaucus* Roberg, *Hedwigia*, vol. 70, p. 137, 1930.

*A. itaconicus* Kinoshita, ex Okunuki, *Bot. Mag. Tokyo*, vol. 45, p. 60, 1931.

Heads dark green, later dull green to grey-brown, radiate, irregular in outline, mop-like rather than spherical, 75–150  $\mu$  diam., 40–60  $\mu$  deep. Stalks smooth, hyaline or tinted yellowish-green in upper part, 0.5–3 mm.  $\times$  8–15  $\mu$ , walls 0.5–1  $\mu$  thick. Vesicles globose to flask-shaped, 15–30  $\mu$  diam., fertile over upper three-quarters of surface. Sterigmata in 1 series, not crowded, 6–12  $\mu \times$  3.5–5  $\mu$ , vase-shaped, tapering only slightly to apex and closely resembling the first conidium. Conidia at first smooth, highly elliptical, later generally coarsely verrucose or wrinkled, occasionally remaining smooth, elliptical, pyriform, or almost globose, very variable, 4–12  $\mu \times$  4–8  $\mu$ , in separate, loose, radiate chains. Perithecia bright yellow, darkening somewhat in age, subglobose, 75–120  $\mu$  diameter, not enclosed in hyphal weft. Asci globose, about 11  $\mu$  diameter. Ascospores lens-shaped, circular in plan, 4.5–5.5  $\mu$  diameter, elliptical in elevation, 3.5–4.5  $\mu$  deep, with median groove either bounded by projecting membranes 0.5–1  $\mu$  wide, or without membranes, or again showing clear elliptical outline with no sign of groove, or at most a slight flattening of the ends.

Czapek colony restricted, more or less floccose, varying in appearance with the strain and conditions of culture, some becoming quickly ascosporic with suppression of conidial formation and consequent predominance of yellow colouration, others spreading widely, with little or no formation of perithecia, appearing dark green, browning with age, or tinged in zones dark yellow or rust colour due to coloured inclusions within, or accretions upon the vegetative hyphae. Reverse various shades of greenish-yellow to rusty-brown. Some staining the media, others not.

Habitat: Silk and cotton fabrics, diseased bee-larvae, tobacco, dried fruit, soil, dead plant parts in glasshouse, sawn timber, jams and preserves, hessian meat wraps, grass seed, air-exposed plates in milking sheds, dairy factories, workrooms and hospital wards, cheddar cheese, leather, sheep-skins, beef dripping, rolled oats and oatmeal, mouldy wheat, barley, peas and bread. (49 isolants.)

The writer has followed Wehmer and Lindau in adopting the specific name *glaucus* Link as covering the range of forms, here listed as synonyms, included in the "*A. glaucus*" group of Thom and Church. Divisions in general rest upon the relative morphology of the ascospores and show a graduated range making the delimitation of any particular form very difficult. Smith (1931), discussing the 42 strains of the "*A. glaucus*" group examined by him, divides these into 4 species, *A. repens*, *A. ruber*, *A. amstelodami* and *A. chevalieri*, mainly on ascosporic, secondarily on cultural characters. Among the 49 strains collected in New Zealand, though the majority agree with his delimitation of *A. repens*, there is a range of ascosporic character covering all four "species," but the writer has not been able to correlate them with the associated secondary cultural characters of Smith. Failing a clear line of demarcation in the conidial stage, differences in the ascosporic stage should not be used to separate species of the "imperfect" genus *Aspergillus* however valid they may be in the classification of the "perfect" genus *Eurotium*.

6. *A. versicolor* (Vuillemin) Tiraboschi, *Ann. Bot. Rome*, vol. 7, p. 9, 1908.

*S. versicolor* Vuill., ex Mirsky, *Thèse Méd. Nancy*, no. 27, p. 15, 1903.

\**S. ambari* Beaurgd., *Ann. Microgr.*, vol. 10, p. 255, 1898.

*S. polychroma* Ferraris. *Fl. Ital. Crypt. Hyph.*, p. 640, 1906.

*A. flavo-viridescens* Hanzawa., *Jour. Coll. Agr. Imp. Univ. Sapporo*, vol. 4, p. 232, 1911.

*A. globosus* Jensen, *Cornell. Agric. Exp. Sta. Bul.*, 315, p. 482, 1912.

*S. sydowi* Bain. and Sart., *Ann. Mycol.*, vol. 11, p. 25, 1913.

*S. tunetana* Langeron, *Bul. Soc. Path. Exot.*, vol. 17, p. 345, 1924.

*A. sydowi* (Bain. and Sart.) Th. and Ch., *The Asperg.*, p. 147, 1926.

*S. camaleao* Sart., Sart. and Meyer, *Ann. Myc.*, vol. 28, p. 360, 1930.

*A. humicola* Chaudhuri and Sachar, *Ann. Myc.*, vol. 32, p. 97, 1934.

Heads variable in colour, with green shades dominant while colony is in vigorous growth, usually merging into zones in which the heads are yellowish-orange or cinnamon, radiate, hemispherical when young, remaining so or becoming somewhat columnar in age, 40–150  $\mu$  diameter. Stalks smooth, generally colourless, sometimes somewhat brownish towards apex, 200–500  $\mu \times 3.5$ –8  $\mu$ , walls 1–1.5  $\mu$  thick. Vesicles generally flask-shaped, sometimes almost globose, fertile on apical two-thirds or on nearly the whole surface, 10–25  $\mu$  diameter. Sterigmata in 2 series, primary 4–7  $\mu \times 3 \mu$ , secondary 6–9  $\mu \times 2$ –2.5  $\mu$ , usually 5 per primary, vase-shaped with well-marked apical tube, with axis more or less perpendicular to surface of vesicle. Conidia globose, coarsely or finely asperulate or almost smooth, 3–3.5  $\mu$ , exceptionally 2.5 or 4  $\mu$ , usually in loose radiating chains. Perithecia not observed. Sclerotia reddish-yellow, present in some strains, when fully developed egg-shaped, 200  $\times$  140  $\mu$ , generally represented by irregular groups of "Hülle" cells.

Czapek colony generally strong-growing, floccose, becoming mealy or velutinous in age, coloured various shades of green, generally emerald green, but sometimes blue-green, sometimes merging into bands of yellow, orange, or cinnamon towards periphery. Margin wide, white generally tinged pink. Reverse yellow to orange and finally deep maroon, often prominently zoned. Media coloured pink to claret.

Habitat: Air-exposed plates in library and citrus packing shed, butter, cheese and cheese "starter" culture, timber, tobacco, borax lemon-washing solution, cork of hair-oil bottle, cork composition washers, annatto seed, mouldy peas and beans, tank-water, and wheat. (32 isolants.)

7. *A. flavus* Link, *Obs. Ord. Plant. Nat.*, vol. 1, p. 16, 1809.

*A. oryzae* (Ahlburg) Cohn, *Jahresb. Schles. Gesell. Vaterl. Cultur*, vol. 61, p. 226, 1884.

*A. variabilis* Gaspar., *Atti. Soc. Tosc. Nat. Sci.*, Mem. 8, p. 326, 1887.

*A. wehmeri* Cost. and Lucet, *Ann. Sci. Nat. Bot.*, Ser. IX, vol. 2, p. 162, 1905.

*A. pseudoflavus* Saito, *Centralb. Bakt.*, II, vol. 18, p. 34, 1907.

*A. effusus* Tiraboschi, *Ann. di Bot.*, vol. 7, p. 10, 1908.

\* In conformity with general usage *versicolor* has been retained as the specific name for this group of strains, although *ambari* has apparent priority.

*A. gymnosardae* Yukawa, *Jour. Coll. Agr. Imp. Univ. Tokyo*, vol. 1, p. 362, 1911.

*A. parasiticus* Speare, *Haw. Sug. Pl. Exp. Sta., Path. and Phys. Ser.*, Bul. 12, p. 38, 1912.

*S. pseudo-flava* (Saito) Sacc., *Syll. Fung.*, vol. 22, p. 1260, 1913.

*A. flavus* f. *maydis* Ciferri, *Bul. Soc. Bot. Italy*, No. 7, p. 75, 1921.

*A. archaeoflavus* Blwz., *Ann. Myc.*, vol. 31, p. 77, 1933.

Heads light greenish-yellow, dark yellow-green to umber in age, variable, at first radiate, becoming loosely columnar in age, 75–150  $\mu$  diameter. Stalks rough from accretions that wash off in mounting fluid leaving scars or pits on the colourless walls, 300–800  $\mu \times 7$ –12  $\mu$ , walls 1.5–2  $\mu$  thick. Vesicles globose or nearly so, 20–50  $\mu$  diameter, fertile on upper three-quarters of surface. Sterigmata 1 or 2 series, primary 6–8  $\mu \times 4 \mu$ , secondary 7–10  $\mu \times 2.5$ –3  $\mu$ , often 1, seldom more than 2 per primary, tapering abruptly to apex without defined apical tube. Conidia globose, pyriform or broadly elliptical, smooth or more or less wrinkled, 3–5  $\mu$  in long axis. Perithecia not observed. Sclerotia produced by some strains, at first as white web of fine aerial hyphae, later becoming globose, black, to 700  $\mu$  diameter, frequently aggregated into masses.

Czapek colony spreading, thin, mealy, light greenish-yellow, darkening to dull yellowish-green in age. Reverse tinted yellow darkening to yellow-brown in age.

Habitat: Pelts, oatmeal, wheat, air-exposed plate in workshop, lucerne stem, canvas, decaying board. (16 isolants.)

8. *A. ustus* (Bain.) Th. and Ch., *The Asperg.*, p. 152, 1926.

*S. usta* Bain., *Bul. Soc. Bot. France*, vol. 28, p. 78, 1881.

*A. luteo-virescens* Blwz., *Ann. Myc.*, vol. 31, p. 80, 1933.

Heads from white through shades of grey, olive-grey, yellow, yellow-brown towards fuscous, with often a greenish cast, but no true green colour, in old cultures purplish vinaceous at times, hemispherical to almost columnar. Stalks smooth, sinuous, few septate, usually partly coloured some shade of brown, to 1 mm. from submerged hyphae, up to 0.5 mm. when arising from aerial hyphae, by 5–10  $\mu$ , walls rather thin. Vesicle 10–20  $\mu$  diameter. Sterigmata colourless, semi-radiate, loosely arranged into 2 series, primary 5–8  $\mu \times 3 \mu$ , secondary 7–9  $\mu \times 2$ –2.5  $\mu$ . Conidia globose, spinulose or with fine faint bars of rosy, reddish-yellow or vinaceous colour, about 3.6  $\mu$  (3.5–4  $\mu$ ), with chains forming fairly compact columns in old cultures. Some strains show sterile clusters of thick-walled helicoid cells, comparable to the "Hülle" cells of *A. nidulans*, but perithecia have not been found. Colonies more or less felted, floccose, with fine hyphae. Reverse through shades of yellow, orange and brown.

Habitat: "Widely separated sources."

Description from Thom and Church (*l.c.*)

Blochwitz (*Ann. Myc.*, vol. 27, p. 223, 1929) gives colour of heads from substratum as copper-red, of those from aerial hyphae, clear-red-brown, fawn, grey-brown, grey-green, green.

(Not as yet found in New Zealand.)

9. *A. wentii* Wehmer, *Centralb. Bakt.*, II, vol. 2, p. 149, 1896.

Heads at first yellow, soon darkening to chocolate-brown, radiate, globose, 150–300  $\mu$  diameter. Stalk smooth, colourless, up to 3 mm.  $\times$  10–15  $\mu$ , walls 1.5–3  $\mu$  thick. Vesicle globose, 25–75  $\mu$  diameter, thick-walled, fertile over whole surface. Sterigmata in 1 series, to 35  $\mu \times 4 \mu$ , or 2 series, primary 7–12  $\mu \times 3$ –4  $\mu$ , secondary 6–14  $\mu \times 2$ –5–3  $\mu$ , sometimes growing out up to 50  $\mu$  as penicilliate branch, tapering abruptly to blunt apex without defined apical tube. Conidia broadly elliptical to globose, brownish, wrinkled, 4–5  $\mu$  diameter, outer wrinkled wall persistent, holding conidial chains together in mounts. Perithecia or sclerotia not observed.

Czapek colony generally deeply floccose, slowly turning yellow then chocolate with the developing heads. Reverse yellow, dark reddish-brown in age. Media lightly stained reddish-yellow.

Habitat: Annatto seed, anemone bulbs, hessian meat wrap, soil, cork insulators, macaroni, bread, shoe leather. (10 isolants.)

10. *A. alliaceus* Th. and Ch., *The Asperg.*, p. 163, 1926.

*A. sacchari* Chandhari and Sachar, *Ann. Myc.*, vol. 32, p. 95, 1934.

Heads yellow or becoming ochre to brown in age, up to 200  $\mu$  diameter. Stalks smooth, colourless, up to 1.5 mm.  $\times$  up to 15  $\mu$ , walls 1.5  $\mu$  thick, breaking with rough or ragged edges. Vesicles up to 50  $\mu$  diameter, with wall 1.8–2  $\mu$  thick, showing prominent pores at bases of sterigmata. Sterigmata in 2 series, primary 7–12  $\mu \times 2$ –4  $\mu$ , secondary 7–8  $\mu \times 2 \mu$ , colourless. Conidia (smooth?) faintly yellowish, elliptical to globose 3  $\mu \times 2$ –5  $\mu$  to 3  $\mu$  diameter.

Sclerotia soon abundant, at first white, later becoming black without yellow or orange colours, ovate to elliptical up to 500  $\mu$ –700  $\mu$  in horizontal diameter, up to 1 mm. or more in vertical axis, with a depression or pore at apex. Perithecia not found.

Czapek colony with white floccose mycelium spreading rapidly over the surface of the medium and quickly producing abundant sclerotia. Conidial heads few and scattered.

Habitat: Reported by Walker and Lindgren as pathogenic on onions and by Taubenhaus and Alstatt as pathogenic on cacti. Thom and Church isolated it from a dead "blister-beetle."

Description from Thom and Church, *The Asperg.*, p. 163, 1926. See note to *A. quercinus* (Bain.) Th. and Ch., p. 255, below. (Not as yet found in New Zealand.)

11. *A. ochraceus* Wilhelm, *Beitr. z. Kenntn. d. Pilzgatt. Asperg.*, p. 66, 1877.

*A. elegans* Gasp., *Atti Soc. Tosc. Sci. Nat. Pisa*, Mem. 8, p. 328, 1887.

*A. ochracea* Delacr., *Bul. Soc. Myc.*, vol. 7, p. 109, 1891.

*S. delacroixii* Sacc., *Syll. Fung.*, vol. 10, p. 527, 1892.

*A. ostianus* Wehmer, *Bot. Centralb.*, vol. 80, p. 449, 1899.

*A. auricomma* Gueguen, *Bul. Soc. Myc.*, vol. 15, p. 171, 1899.

*A. ochraceus* var. *microspora* Tiraboschi, *Ann. di Bot.*, vol. 7, p. 14, 1908.

*A. melleus* Yukawa, *Jour. Coll. Agr. Imp. Univ. Tokyo*, vol. 1, no. 3, p. 366, 1911.

*S. ochroleuca* Speg., *An. Mus. Nac. Buenos Aires*, Ser. III, t. 13, 1911.

*A. spadix* Amons, *Arch. Suiker. Nederl.-Ind.*, vol. 29, p. 12, 1921.

*A. delacroixii* (Sacc.) Th. and Ch., *The Asperg.*, p. 190, 1926.

*A. hennebergi* Blwz., *Ann. Myc.*, vol. 33, p. 238, 1935.

Heads yellow to ochraceous, radiate, globose. Stalks thickly set with yellow-brown warts, leaving pits when mounted, yellow, several mm.  $\times$  up to  $15\ \mu$ , walls  $3\ \mu$  thick. Vesicles globose  $60\text{--}70\ \mu$  diameter, fertile over whole surface. Sterigmata 2 series, primary often septate and up to  $70\ \mu$  long, secondary  $10\text{--}12\ \mu \times 1.5\text{--}2.5\ \mu$ . Conidia globose or elliptical, smooth or delicately roughened,  $5\ \mu \times 3.5\ \mu$  or  $3.5\text{--}4.5\ \mu$  diameter. Some strains with abundant sclerotia, yellowish-brown,  $400\text{--}700\ \mu$  diameter.

Czapek colony varying with presence or absence of sclerotia, ochraceous or in shades of orange to vinaceous or in purple tones. Submerged mycelium colourless to yellow, orange, or purplish shades.

Habitat: Bread, decaying plants, gelatine, dried fish.

Description from Thom and Church, *The Asperg.*, p. 184; 1926.

(Not as yet found in New Zealand.)

12. *A. tamarii* Kita, *Centraltb. Bakt.*, II, vol. 37, p. 433, 1913.

Heads brown, becoming darker with age, radiate, hemispherical or globose,  $70\text{--}120\ \mu$  diameter. Stalks usually smooth, colourless,  $0.2\text{--}1.2\ \text{mm.} \times 4\text{--}10\ \mu$ , showing septa in age. Vesicles globose or flask-shaped, upright or drooping on the stalk, from  $15\text{--}17\ \mu$  to  $22 \times 24\ \mu$ , walls colourless or faintly yellow, fertile over whole surface or only on the upper portion. Sterigmata clavate, in 1 series,  $9 \times 4\ \mu$  to  $10 \times 5\ \mu$ . Conidia brownish-yellow or green-brown, globose, heavily warted,  $3\text{--}6\ \mu$ .

Habitat: Manufacture of soya sauce in Japan.

Description from Kita, *l.c.*

Thom and Church, *The Asperg.*, p. 194, 1926, describe their strains as follows:—

Heads at first colourless, then passing through orange-yellow shades to brown in old colonies, not showing true green, variable in size, from more or less columnar to almost but not quite globose, up to  $350\ \mu$  diameter, with radiating chains and columns of conidia. Stalks arising from submerged hyphae 1 to several mm.  $\times 10\text{--}12\ \mu$ , walls thick  $1\text{--}2\ \mu$ , becoming abruptly thinner at base of vesicle, pitted more prominently in upper than lower half (often appearing as rough or echinulate with low magnifications) and frequently showing irregular thickenings within. Vesicles  $25\text{--}50\ \mu$  diameter. Sterigmata 1 series in small heads, 2 series in large heads, primary commonly  $7\text{--}10\ \mu \times 3\text{--}4\ \mu$ , becoming  $20\text{--}25\ \mu$  long in gigantic heads, secondary  $7\text{--}10\ \mu \times 3\ \mu$ . Conidia more or less pyriform toward globose, tuberculate especially at the distal end in the chain, 5, 6, occasionally up to  $8\ \mu$  in diameter, rough from prominent masses and bars of orange-yellow colouring matter deposited under the loose outer wall upon the firm inner wall. Sclerotia occasionally produced, usually purple or reddish-purple, globose to pyriform with apex white.

(Not as yet found in New Zealand.)

13. *A. citrisporus* von Hohnel, *Sitzungsber. K. Akad. Wiss. Wien, Math-Naturw.*, Kl. III, 1 Abt., p. 987, 1902.

Heads yellow, then golden, finally fulvous, radiate, up to  $500\ \mu$  diameter. Stalks obscurely pitted (colourless?),  $1\text{--}2\ \text{mm.} \times 20\text{--}25\ \mu$ , thin ( $1\ \mu$  or less mostly). Vesicles nearly globose,  $30\text{--}50\ \mu$ .

diameter, fertile over nearly the entire surface. Sterigmata 1 series,  $8-12\ \mu \times 3-4\ \mu$ . Conidia yellow or golden, then brown, lemon-shaped,  $5-9\ \mu \times 5-6\ \mu$ , rough from irregularly branching ridges of yellow to brown colouring matter between the inner and outer wall. Sclerotia occasionally found.

Habitat: Excrement of insect larvae.

Description from Thom and Church, *The Asperg.*, p. 192, 1926.

(Not as yet found in New Zealand.)

14. *A. terreus* Th. and Ch., *Amer. Jour. Bot.*, vol. 5, p. 85, 1918.

*A. fuscus* Amons, *Arch. Suiker. Ned.-Ind.*, vol. 29, p. 8, 1921.

*S. hortai* Langeron, *Bul. Soc. Path. Exot.*, 15, p. 383, 1922.

*A. galeritus* Blwz., *Ann. Myc.*, vol. 27, p. 205, 1929.

*A. carneus* Blwz., *ibid.*, vol. 31, p. 81, 1933.

*A. boedijnii* Blwz., *ibid.*, vol. 32, p. 83, 1934.

Heads flesh coloured, darkening in age to cinnamon, columnar,  $120-300\ \mu \times 50-70\ \mu$ . Stalk smooth, colourless,  $100-180\ \mu \times 5-7\ \mu$ , walls up to  $1\ \mu$  thick. Vesicle sub-globose to flask-shaped,  $15-22\ \mu$  diameter, fertile over nearly the whole surface. Sterigmata 2 series, primary  $6-8\ \mu \times 2.5\ \mu$ , secondary  $6-8\ \mu \times 1.5-2\ \mu$ , tapering abruptly to apex without defined apical tube, with axes more or less parallel to axis of stalk, 1, 2 or 3 per primary. Conidia globose, smooth,  $2.3-3\ \mu$  diameter, in long parallel chains adherent into solid columns. Perithecia or sclerotia not observed.

Czapek colony spreading, thin, velutinous, densely covered with flesh to cinnamon coloured heads. Reverse yellowish-green.

Habitat: Rolled oats and oatmeal, wheat. (4 isolants.)

15. *A. cervinus* Massee, *Kew Misc. Bul.*, 4, p. 158, 1914.

*A. gratioli* Sart., *Compt. Rend. Acad. Sci.*, vol. 170, p. 523, 1920.

Heads flesh coloured, darkening to cinnamon in age, radiate, nearly globose, loose, to  $150\ \mu$  diameter. Stalk smooth, colourless,  $150-250\ \mu \times 6-8\ \mu$ , walls about  $1\ \mu$  thick. Vesicle globose,  $15-20\ \mu$  diameter, fertile over whole surface. Sterigmata 1 series,  $4-6\ \mu \times 2.3\ \mu$ , vase shaped with well-marked apical tube, with axis perpendicular to surface of vesicle. Conidia globose, smooth, coloured reddish-yellow,  $3-3.5\ \mu$  diameter, often showing remains of connective as small papillae at each end. Perithecia or sclerotia not observed.

Czapek colony spreading, thin, velutinous to mealy, flesh coloured, darkening to cinnamon with age. Reverse café-au-lait. Strong musty odour.

Habitat: Soil, North Auckland. (1 isolant.)

Massee describes his strain from soil near Khartoum as follows:—

Colonies forming an effused fawn-coloured stratum on culture media. Stalks sparse,  $80-35\ \mu \times 8-10\ \mu$ . Sterigmata in 1 series:  $7-8\ \mu \times 3\ \mu$ . Conidia globose, smooth,  $2\ \mu$ .

Thom and Church (*The Asperg.*, p. 150, 1926) note having examined a strain from Porto Rico soil close to this form.

16. *A. flavipes* (Bain. and Sart.) Th. and Ch., *The Asperg.*, p. 156, 1926.

*S. flavipes* Bain. and Sart., *Bul. Soc. Myc. France*, vol. 27, p. 90, 1911.

*A. niveus* Blwz., *Ann. Myc.*, vol. 27, p. 205, 1929.

*A. archiflavipes* Blwz., *Ann. Myc.*, vol. 32, p. 84, 1934.

Heads white, persistently so or with some strains in pale to deep avellaneous shades, mostly columnar. Stalks smooth, occasionally with disk-like accretions, yellow under the microscope, in mass some shade of buff to vinaceous buff, with colour mostly localised in outer layers of cell wall,  $300-500\ \mu \times 4-5\ \mu$  or up to  $2.3\ \text{mm.} \times 8-10\ \mu$ . Vesicles sub-globose to elliptical, up to  $20\ \mu \times 30\ \mu$  in the largest forms, usually twice diameter of stalk in the smaller forms, fertile on apical surface in smaller forms, covering the vesicle in larger forms. Sterigmata in 2 series, primary  $4-8\ \mu \times 2-3\ \mu$ , secondary  $5-8\ \mu \times 1.5-2\ \mu$ . Conidia sub-globose, smooth, colourless or nearly so in mounts,  $2-3\ \mu$  diameter, in chains aggregated to form columns. Sclerotia as submerged or protruding dark brown to black masses and aggregations of Hülle cells. Perithecia not reported.

Czapek colony varying from almost velvety with abundant development of even-sized white heads to floccose aerial mycelium, grey, buff to vinaceous buff, with sparse development of long stalked white calyptate heads or more closely felted forms with brown sclerotia or brown crusts upon or just above the substratum, and to colonies with more or less numerous yellow aggregations of sigmoid Hülle cells. Submerged mycelium from persistently colourless to yellow, orange or yellow-brown.

Description from Thom and Church (*The Asperg.*, p. 155, 1926).

(Not as yet found in New Zealand.)

17. *A. candidus* Link, *Obs. Ord. Plant. Nat.*, vol. 1, p. 16, 1809.

*A. albus* Wilhelm, *Beitr. Kennt. Pilzg. Asper.*, p. 69, 1877.

*S. candida* Sacc., *Mich.*, vol. 1, p. 91, 1877.

*S. candidula* Bain., *Sacc. Syll. Fung.*, vol. 4, p. 73, 1886.

*A. fimetarius* Peck, *New York St. Mus. Bot. Rept.*, 42, p. 128, 1889.

*A. dubiosus* Lind., *Rabh. Krypt. Fl.*, vol. 8, p. 151, 1907.

*A. niveocandidus* Lind., *l.c.*, p. 151, 1907.

*A. okazakii* Okazaki, *Centralb. Bakt.*, II, vol. 19, p. 481, 1907.

*S. alba* (Wilhelm) Sacc., *Syll. Fung.*, vol. 22, p. 1260, 1913.

*S. szurakiana* Moesz. G., *Bot. Közlem.*, vol. 19, p. 59, 1921.

Heads white, persistently so or turning cream-coloured in age, radiate, globose,  $100-250\ \mu$  diameter. Stalks smooth, colourless,  $0.5-2\ \text{mm.} \times 8-12\ \mu$ , walls  $1.5-2\ \mu$  thick. Vesicles globose,  $25-50\ \mu$  diameter, fertile over whole surface. Sterigmata in 2 series, primary  $15-25\ \mu \times 3.5-4\ \mu$ , secondary  $8-10\ \mu \times 2.5\ \mu$ , usually 5 per primary, tapering directly to apex without marked apical tube. Conidia at first elliptical, later globose, smooth, colourless,  $2.8-3.5\ \mu$ , normally  $3\ \mu$  diameter. Perithecia or sclerotia not observed.

Czapek colony spreading thin velutinous-mealy, pure white or with tinge of yellow in age. Reverse uncoloured or cream.

Habitat: Macaroni, split peas, wheat. (3 isolants.)

18. *A. niger* Van Tieghem *Ann. Sci. Nat. Bot.*, V, vol. 8, p. 240, 1867.

*Ustilago phoenicis* Corda, *Icon. Fung.*, IV, p. 9, 1840.

*A. phaeocephalus* Dur. and Mont., *Fl. Alg.*, p. 342, 1849.

*A. nanus* Mont., *Syll. Gen. Spec. Crypt.*, p. 800, 1856.

*S. antacustica* Cramer, *Vrtlschr. Naturf. Gesell.*, vol. 4, p. 325, 1859.

*A. fuliginosus* Peck, *Bul. Buff. Soc. Nat. Sci.*, vol. 1, p. 69, 1874.

*S. nigra* van Tieg., *Bul. Soc. Bot. France*, vol. 24, p. 102, 1877.

*S. carbonaria* Bain., *ibid.*, vol. 27, p. 27, 1880.

*S. fusca* Bain., *l.c.*, p. 29, 1880.

• *A. subfuscus* Johan-Olsen, *Meddel. Naturh. Kristiania*, 1885.

*A. violaceo-fuscus* Gasp., *Atti Soc. Tosc. Sci. Nat. Pisa*, Mem. 8, fasc. 2, p. 326, 1887.

*A. ustilago* Beck, *Itin. Princip. S. Coburgi.*, vol. 2, p. 148, 1888.

• *S. phoenicis* (Corda) Pat. and Delacr., *Bul. Soc. Myc. France*, vol. 7, p. 119, 1891.

*A. ficum* (Reich.) Henn., *Hedwigia*, vol. 34, p. 86, 1895.

† *S. pulverulenta* McAlp., *Agr. Gaz. N.S. Wales*, vol. 7, p. 302, 1897.

*S. castanea* Pattsn., *Bul. Torr. Bot. Club*, vol. 27, p. 284, 1900.

*A. luchuensis* Inui, *Jour. Col. Sci. Imp. Univ. Tokyo*, vol. 15, p. 469, 1901.

*A. pernicius* Inui, *l.c.*, p. 473, 1901.

*S. pseudonigra* Cost. and Lucet, *Bul. Soc. Myc. France*, vol. 19, p. 33, 1903.

*A. strychni* Lindau, *Hedwigia*, vol. 43, p. 306, 1904.

*A. japonicus* Saito, *Bot. Mag. Tokyo*, vol. 20, p. 61, 1906.

• *S. luteo-nigra* Lutz, *Bul. Soc. Bot. France*, vol. 53, p. L, 1906. —

*A. batatae* Saito, *Centralb. Bakt.*, II, Vol. 18, p. 34, 1907.

*A. welwitschiae* (Bres.) Henn., ex Wehmer, *Centralb. Bakt.*, II, vol. 18, p. 394, 1907.

• *S. insueta* Bain., *Bul. Soc. Myc. France*, vol. 24, p. 85, 1908.

*S. dipus* Ferd. and Winge, *Bot. Tids.*, vol. 30, p. 220, 1910.

*Aspergillopsis nigra* (Van Tieg.) Speg., *An. Mus. Nac. Buenos Aires*, III, vol. 13, p. 435, 1911.

† *Aspergillopsis pulchella* Speg., *l.c.*, p. 436, 1911.

*A. atropurpureus* A. Zimm., *Centralb. Bakt.*, II, vol. 8, p. 218, 1912.

*A. fuscus* Schiem., *Ztschr. Ind. Abst. Vererb.*, vol. 8, p. 1, 1912.

• *A. cinnamomeus* Schiem., *l.c.*, p. 1, 1912.

† *A. awamori* Usami, *Myk. Zbl.*, vol. 4, p. 194, 1914.

*A. pulverulentus* (McAlp.) Thom, *Jour. Agr. Res.*, vol. 7, p. 10, 1916.

*A. phoenicis* (Corda) Thom, *l.c.*, p. 11, 1916.

*A. carbonarius* (Bain.) Thom, *l.c.*, p. 12, 1916.

*A. schiemanni* (Schiem.) Thom, *l.c.*, p. 13, 1916.

† *A. fumaricus* Wehmer, *Ber. Deut. Chem. Ges.*, vol. 51, p. 1663, 1918.

• *A. insuetus* (Bain.) Th. and Ch., *The Asperg.*, p. 153, 1926.

*A. luteo-niger* (Lutz) Th. and Ch., *l.c.*, p. 166, 1926.

*A. pulchellus* (Speg.) Th. and Ch., *l.c.*, p. 181, 1926.

† *A. minutus* Abbot, *Iowa St. Coll. Jour. Sci.*, vol. 1, 1927.

Heads black, sometimes with brown or purple shade, radiate, globose, compact or with conidial chains adhering in sections, showing cruciform or stellate outline viewed from above, 150–750  $\mu$  diameter. Stalks smooth, colourless or tinted brown towards apex, very variable in size, from 200  $\mu$  to several mm.  $\times$  10–30  $\mu$ , with walls 1.5–3  $\mu$  thick, often showing irregular inner outline. Vesicles globose, generally tinted brown, thick walled, 30–70  $\mu$  diameter, fertile over whole surface. Sterigmata usually coloured brown, normally in 2 series, exceptionally in 1 series, primary usually 15–24  $\mu \times$  4–4.5  $\mu$ , or up to 45  $\mu \times$  5  $\mu$ , exceptionally, especially in heads showing 1 series, 7–10  $\mu \times$  3  $\mu$ , secondary 6–8  $\mu \times$  2.5–3  $\mu$ , usually 5 per primary, tapering to short apical tube. Conidia dark, rough, exceptionally almost or quite smooth, sometimes spinulose or verrucose, but usually showing tubercles of brown colouring matter arranged more or less in patterns on outer wall or between outer

and inner wall, in the great majority of strains regularly globose, 3.5–4  $\mu$  diameter, exceptionally somewhat elliptical up to 6  $\mu$  in long axis. Sclerotia present in some strains, globose, 500–600  $\mu$  diameter, at first white, later pale yellow. Perithecia not observed.

Czapek colony usually very vigorous, spreading, more or less floccose, at first white, soon becoming covered with concentric rings of dark-brown, black, or dark purple fruiting heads which finally coalesce into an almost solid crust, aerial hyphae often tinged canary-yellow. Reverse colourless to bright yellow, greenish-yellow or brown.

Habitat: Annatto seed, tent calico, bulbs, germinating seeds, soils, pelts, stored onions, macaroni, rolled oats, oatmeal, malt, wheatmeal, rice, exposed plates in library, workrooms, clothing stores, and hospital. (23 isolants.)

*A. nanus* Mont., *A. luchuensis* Inui, *A. perniciosus* Inui and *A. japonicus* Saito have here been listed as synonyms of *A. niger* van. Tieg., since, in agreement with Thom and Church (*The Asperg.*, p. 171, 1926), the writer does not consider the absence of secondary sterigmata alone as a sufficiently constant character to warrant separation. Several New Zealand strains of *A. niger* show heads with either 1 or 2 series of sterigmata in the same culture, and one strain, otherwise indistinguishable from type, has sterigmata persistently in a single series. To quote Thom and Church (*l.c.*) "we appear to be dealing with a cosmopolitan, almost omnivorous group of races or species which show great variability with probably many natural or induced variations."

### Doubtful Species.

In general recorded only once, not as yet identified in New Zealand.

#### KEY.

Heads green.			
Vesicle clavate, sterigmata in 2 series.	..	..	<i>A. pseudoclavatus</i>
Vesicle globose or flask-shaped.			
Sterigmata in 1 series.			
Conidia 2 $\mu$ .	..	..	<i>A. minimus</i>
Conidia 3–4 $\mu$ .	..	..	<i>A. varians</i>
Sterigmata 1 or 2 series.	..	..	<i>A. jeanselmei</i>
Heads grey.			
Conidia 1 $\mu$ .	..	..	<i>A. pusillus</i>
Heads yellow to brown.			
Stalks smooth.			
Sterigmata in 1 series.	..	..	<i>A. gigantosulphureus</i>
Sterigmata in 2 series.			
Stalks yellow.			
Conidia 2.5–3 $\mu$ .	..	..	<i>A. rehmi</i>
Conidia 5.2 $\mu$ .	..	..	<i>S. butyracea</i>
Stalks colourless.	..	..	<i>A. quercinus</i>
Stalks rough.			
Sterigmata in 1 series.	..	..	<i>A. terricola</i>
Sterigmata in 2 series.	..	..	
Conidia smooth 2–3 $\mu$ .	..	..	<i>A. sclerotiorum</i>
Conidia rough 8 $\mu \times 6 \mu$ .	..	..	<i>A. erythrocephalus</i>
Heads rose colour.			
Sterigmata in 1 series.	..	..	<i>A. halophilus</i>
Sterigmata in 2 series.			
Primary sterigmata septate.	..	..	<i>S. basidiosepta</i>
Primary sterigmata not septate.	..	..	<i>S. albo-rosea</i>
Heads cream colour.			
Sterigmata in 1 series.	..	..	<i>A. koningi</i>

**Sterigmatocystis albo-rosea** Sart., Sart. and Meyer, *Ann. Myc.*, vol. 28, p. 358, 1930.

Heads rose-colour, radiate, stalks smooth, non-septate, hyaline, becoming rose-colour,  $125-150\ \mu \times 4.5-5\ \mu$ , vesicles clavate,  $19-32\ \mu \times 9-17\ \mu$ , fertile over whole surface. Sterigmata in 2 series, primary  $6\ \mu \times 3\ \mu$ , secondary to  $9\ \mu$  long, 3 to 5 per primary. Conidia globose, smooth, rose-colour,  $2.5-3\ \mu$  diameter.

Habitat: Skin of decomposing banana.

Description from Sart., Sart. and Meyer (*l.c.*).

**S. basidiosepta** Sart., Sart. and Meyer, *Ann. Myc.*, vol. 27, p. 317, 1929.

Heads rose-colour, darkening to cafe-au-lait in age, radiate. Stalk hyaline, smooth,  $0.8-1\ \text{mm.} \times 12-14\ \mu$ . Vesicle globose,  $50-55\ \mu$ , fertile over whole surface. Sterigmata in 2 series, primary claviform, becoming up to 4 septate under optimum conditions of growth,  $28-30\ \mu$  long, secondary  $12-14\ \mu$  long. Conidia globose, smooth,  $2.5-3\ \mu$ . Sclerotia or perithecia not observed.

Habitat: In crystallizator.

Description from Sart., Sart. and Meyer (*l.c.*).

**S. butyracea** Bainier, *Bul. Soc. Bot. France*, vol. 27, p. 29, 1880.

Colonies butter yellow, including stalks, heads and conidia. Stalks yellow, pitted,  $13-16\ \mu$  diameter. Sterigmata in 2 series, primary up to  $25\ \mu$ , secondary  $10-12\ \mu$  long. Conidia smooth,  $5.2\ \mu$ .

Description from Th. and Ch. (*The Asperg.*, p. 191, 1926).

(Possibly a strain of *A. ochraceus* Wilhelm.)

**Aspergillus erythrocephalus** Berk. and Curt., *Jour. Linn. Soc. Bot.*, vol. 10, p. 362, 1869.

Head radiate. (Colour?) Stalks rough or pitted, up to  $2\ \text{mm.} \times 45-70\ \mu$ , walls  $5-12\ \mu$  thick. Vesicle nearly globose,  $100\ \mu$  diameter, fertile all over. Sterigmata 2 series, primary  $8-10\ \mu$ , secondary  $8-9\ \mu$  long. Conidia  $8\ \mu \times 6\ \mu$ ,  $8-12\ \mu \times 5-9\ \mu$ , finely pitted or roughened with rather thin walls.

Description from Th. and Ch. (*The Asperg.*, p. 197, 1926).

**A. gigantosulphureus** Saito, *Jour. Coll. Sci. Imp. Univ. Tokyo*, vol. 18, art. 5, p. 48, 1904.

Heads yellow, becoming yellow brown. Stalk smooth, colourless, over  $1\ \text{mm.} \times 6-16\ \mu$ , sometimes branched, in age septate. Vesicle flask-shaped  $28-32\ \mu$  diameter, fertile on upper surface only. Sterigmata single,  $24-28\ \mu \times 7\ \mu$ . Conidia globose, smooth or rough  $8-12\ \mu$  diameter. Perithecia not known.

Description from Saito (*l.c.*).

(Saito suggests affinities with *A. osteanus* Wehmer, Thom & Church with *A. glaucus* or *A. oryzae*.)

- A. halophilus** Sart., Sart. and Meyer, *Ann. Myc.*, vol. 28, p. 362, 1930.

Head rose-colour, radiate. Stalks smooth, at first hyaline, later rose-colour 5–7  $\mu$  diameter. Vesicles globose, fertile over whole surface. Sterigmata single, 25  $\mu \times$  6–7  $\mu$ . Conidia globose, rose colour, most coarsely echinulate, variable in size, 5–9  $\mu$ . Sclerotia or perithecia not observed.

Habitat: Cocoa which had been submerged in sea water.

Description from Sart., Sart. and Meyer (*l.c.*).

- A. koningi** Oudemans, *Arch. Neerl.*, vol. 7, ser. 2, p. 248, 1902.

Heads radiate (cream colour?). Stalks hyaline, up to 350  $\mu$  long. Vesicles hyaline, 16–20  $\mu$  diameter. Sterigmata 1 series, 8–10  $\mu \times$  2.5  $\mu$ . Conidia globose, smooth, cream colour, 3  $\mu$ .

Description from Th. and Ch. (*The Asperg.*, p. 127, 1926).

- A. jeanselmei** Ota, *Ann. Parasitologie*, vol. 1, p. 137, 1923.

Stalks smooth, somewhat dark coloured, from 80 or, more commonly, 100–400  $\mu$  long, 4–5  $\mu$  diameter at base to 8  $\mu$  at vesicle, which is 16–29  $\mu$  diameter. Sterigmata in 1 or 2 series, 4–10  $\mu \times$  2–3  $\mu$ . Conidia globose or ovoid, 3.5–6.5  $\mu$  diameter, mostly 5  $\mu$  or less, smooth or in very old cultures somewhat verrucose, greenish becoming reddish-brown in several months.

Description from Th. and Ch. (*The Asperg.*, p. 140) who suggest that this is a variant of *A. nidulans*.

- A. minimus** Wehmer, *Bot. Centralb.*, vol. 80, p. 454, 1899.

Colonies green to grey-green, to dark green or dirty grey. Reverse not coloured or greyish. Heads radiate. Stalk smooth, colourless, 0.3–1 mm.  $\times$  6  $\mu$ . Sterigmata 1 series, 5–7  $\mu \times$  3  $\mu$ , radiate, deciduous in age. Conidia oval, smooth, colourless, about 2  $\mu$  diameter.

Description from Th. and Ch. (*The Asperg.*, p. 127, 1926).

- A. pseudo-clavatus** Purjewitch, *Schrift. Naturforsch. Gesell. Kiev*, 16, 2, p. 309, 1900.

Conidial areas white to intensely green, later grey-green. Stalks 3–5 mm. in length, 25–35  $\mu$  diam. at base, increasing to the vesicle, which is 260–270  $\mu \times$  60–70  $\mu$ . Sterigmata closely packed in 2 series, primary 8–9  $\mu$ , secondary delicate, 2–5  $\mu$  in length. Conidia oval, greyish-green, 3.5–4  $\mu \times$  2.5–3  $\mu$ . Perithecia develop only under special conditions, 60–70  $\mu$  diameter, asci 6–7 (?) in the perithecium, 7–8  $\mu$ . Ascospores colourless oval.

Description from Th. and Ch. (*The Asperg.*, p. 100, 1926).

- A. pusillus** Massee, *Kew Bull. Misc. Inf.*, 4, p. 158, 1914.

Colony grey, effuse. Stalks hyaline, non-septate, 50–75  $\mu \times$  3–4  $\mu$ . Vesicle 10–12  $\mu$  diameter. Sterigmata cylindrical, 3  $\mu \times$  1  $\mu$ . Conidia globose, smooth, almost hyaline, 1  $\mu$  diameter.

Description from Th. and Ch. (*The Asperg.*, p. 127, 1926).

**A. quercinus** (Bain.) Th. and Ch., *The Asperg.*, p. 186, 1926.

*S. quercina* Bainier, *Bul. Soc. Bot. France*, vol. 28, p. 78, 1881.

Colonies colour of clear oak wood, naples yellow, not ochraceous. Stalks smooth, colourless, up to 10 mm.  $\times$  21  $\mu$ . Heads (?) given as 88-3  $\mu$ . Sterigmata in 2 series, equal in length, 10-5  $\mu$ . Conidia globose, smooth, 4-4.2  $\mu$ . Sclerotia very abundant, especially on carrot, up to 0.5 mm., yellow.

Description from Th. and Ch. (*The Asperg.*, p. 187, 1926).

It would appear that *A. quercinus*, *A. alliaceus*, *A. sachari*, and *A. sclerotiorum* are a series of closely related forms differing chiefly in colour of the abundant sclerotia they all form in culture.

**A. rehmsii** Zukal, *Oesterr. Bot. Zeitschr.*, vol. 43, p. 160, 1893.

Mycelium closely woven, yellow to ochre-yellow. Stalks smooth yellow, 400-500  $\mu \times$  5  $\mu$ . Vesicle elliptical oval, 30  $\mu \times$  20  $\mu$ . Sterigmata 2 series, primary 6  $\mu \times$  2-3  $\mu$ , secondary 4  $\mu \times$  1.5  $\mu$ . Conidia roundish "polyhedral," smooth, yellowish, 2.5-3  $\mu$ . Perithecia black, 100-200  $\mu$  diameter, surrounded by yellow weft, bearing Hülle cells. Asci 6-7  $\mu \times$  4-5  $\mu$ . Ascospores elliptical, smooth, translucent grey, about 5  $\mu \times$  3.5  $\mu$ .

Description from Th. and Ch. (*The Asperg.*, p. 137, 1926).

**A. sclerotiorum** Huber, *Phytopath.*, vol. 23, p. 306, 1933.

Heads sulphur-yellow, hemispherical to columnar, up to 140  $\mu$  diameter. Stalks light yellow, pitted, to 1.2 mm.  $\times$  6-12  $\mu$ . Vesicle globose to flask-shaped, up to 40  $\mu$  diameter. Sterigmata 2 series, approximately equal in length, up to 8.5  $\mu$ . Conidia globose, smooth, 2-3  $\mu$  diameter, walls slightly tinged yellow. Perithecia not found. Sclerotia abundant, first appearing in cultures 3 days old, globose or sub-globose, white at first, soon becoming light cream and then flesh pink. Pathogenic to apples.

Description from Huber (*l.c.*).

(See note to *A. quercinus* above.)

**A. sulphureus** (Fresen.) Th. and Ch., *The Asperg.*, p. 185, 1926.

*S. sulphurea* Fresenius, *Beitr. Z. Mykol.*, vol. 3, p. 83, 1886.

This species is known only from the imperfect description of Fresenius, and from dried herbarium material, in the interpretation of which Wehmer, Thom and Church and Blochwitz differ.

Thom and Church would apply the name to strains of *A. ochraceus* producing bright yellow heads and not producing sclerotia.

The name should be dropped.

**A. terricola** Marchal, *Rev. Mycologique*, vol. 15, p. 101, 1893.

Colonies "terre d'ombre," umbrinus. Stalks hyaline 0.6-1 mm.  $\times$  7-10  $\mu$ . Vesicle sub-globose, hyaline 30-50  $\mu$ , radiately covered with sterigmata. Sterigmata 12-15  $\mu \times$  4-7  $\mu$ . Conidia umber (Sacc.), ovate or elliptical then globose, rough, with colourless connective.

Description from Th. and Ch. (*The Asperg.*, p. 192, 1926).

**A. terricola** var. *americana* Marchal, ex. Th. and Ch., *Am. Jour. Bot.*, vol. 8, p. 125, 1921.

Heads yellow ochre becoming mummy-brown, radiate. Stalks pitted 0.3–0.6 mm.  $\times$  6–8  $\mu$ . Vesicles up to 20  $\mu$  diameter. Sterigmata 1 series, 7–10  $\mu$   $\times$  2.4  $\mu$ . Conidia ovate or nearly globose, tuberculate from colour bars between inner and outer walls, 5  $\mu$   $\times$  3  $\mu$  up to 7  $\mu$   $\times$  5  $\mu$  occasionally 5–8  $\mu$  diameter.

Description from Th. and Ch. (*l.c.*).

(Possibly synonymous with *A. tamarii* Kita, and, if so, should have priority.)

**A. varians** Wehmer, *Bot. Centralb.*, vol. 80, p. 460, 1899.

Colonies a beautiful green, becoming darker and even brown in age. Heads radiate. Stalks smooth, colourless, 1–2 mm.  $\times$  10–14  $\mu$ , not crowded on most media. Vesicles globose or oval, with rough wall and yellow-green contents, 25–30  $\mu$  diameter, fertile over whole surface. Sterigmata in 1 series, 16–25  $\mu$   $\times$  3–4  $\mu$ . Conidia globose, smooth or finely granular, 3–4  $\mu$  diameter. Perithecia and sclerotia not found.

Description from Th. and Ch. (*The Asperg.*, p. 127, 1926).

### Species Insufficiently Described or Belonging to Other Genera.

#### TO BE DISCARDED.

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## INDEX OF SPECIES.

- S. aerea* Bainier  
*S. alba* Bainier  
*S. alba* (Wilhelm) Saccardo  
*S. alba* Van Tieghem  
*S. albo-lutea* Bainier  
*S. albo-rosea*  
     Sartory, Sartory and Meyer  
*S. albus* Wilhelm  
*A. alliaceus* Thom and Church  
*A. alutaceus* Berkeley and Curtis  
*S. ambari* Beauregard  
*A. amoenus* Roberg  
*A. amstelodami* (Mangin)  
     Thom and Church  
*S. antacustica* Cramer  
*A. arohaeoflavus* Blochwitz  
*A. archiflavipes* Blochwitz  
*A. argentinus* Spegazzini  
*A. atropurpureus* A. Zimmermann  
*A. atrovirens* Karsten  
*S. aurea* Greco  
*A. aureoglaucus* Roberg  
*S. auricoma* Gueguen  
*A. auriculaire* Moquin-Tandon  
*A. aviarius* Peck  
*A. avamori* Usami  
*A. barbae* Castellani  
*S. basidiosepta*  
     Sartory, Sartory and Meyer  
*A. batatae* Saito  
*A. belfanti* Carbone  
*S. bicolor* J. Ray  
*A. boedijnii* Blochwitz  
*A. bouffardi* Brumpt  
*A. bronchialis* Blumentritt  
*A. brunneo-fuscus* See  
*A. brunneo-virens* Delacroix  
*A. brunneus* Delacroix  
*S. butyracea* Bainier  
*A. byssoides* Sprengel  
*A. cacao*  
*A. caesiellus* Saito  
*A. calyptratus* Oudemans  
*A. calyptratus* var. *italicus* Ferraris  
*S. cameleo* Sartory, Sartory and Meyer  
*S. candida* Saccardo  
*S. candidula* Bainier  
*A. candidus* Link  
*S. carbonaria* Bainier  
*A. carbonarius* (Bainier) Thom  
*S. carnea* Van Tieghem  
*A. carneus* Blochwitz  
*A. carneolus* Saccardo  
*S. castanea* Patterson  
*A. cellulosa* Hopffe  
*A. cervinus* Massee  
*A. chevalieri* (Mangin)  
     Thom and Church  
*S. chlorina* Cooke and Massee  
*A. cimmerius* Berkeley and Curtis  
*A. cinereosens* Bainier and Sartory  
*A. cinereus* Spegazzini  
*A. cinnamomeus* Schieman  
*A. citrisporus* Von Höhnel  
*A. clavatus* Desmazières  
*A. clavellus* Peck  
*A. condylomatae* Greco  
*A. conicus* Blochwitz  
*A. conoideus* Sprengel  
*A. cookei* (Cooke) Saccardo  
*A. corolligena* Massee  
*S. coronata* Van Tieghem  
*S. coronella* Costantin  
*A. cracatus* Berkeley and Curtis  
*A. cucurbitaceus* Berkeley and Curtis  
*A. curtisii* Berkeley  
*S. dasytricha* Ellis and Everhart  
*A. delacroixii* Saccardo and Sydow  
*A. delacroixii* (Saccardo)  
     Thom and Church  
*S. dipus* Ferdinandsen and Winge  
*A. disjunctus* Bainier and Sartory  
*S. dubia* (B. and Br.) Saccardo  
*A. dubiosus* Lindau  
*A. dubius* Corda  
*A. echinosporus* Sorokine  
*A. echinulatus* (Delacroix)  
     Thom and Church  
*A. effusus* Tiraboschi  
*A. elegans* Gasperini  
*A. erythrocephalus* Berkeley & Curtis  
*S. ferruginea* Cooke  
*A. ferrugineus* Fries  
*A. ferrugineus* Fuckel  
*A. ferrugineus* Link  
*A. fiovum* (Reich.) Hennings, P.  
*A. fimetarius* Peck  
*A. fimeti* Saccardo  
*A. fischeri* Wehmer  
*A. flavescens* Wreden  
*A. flavus* Berkeley and Broome  
*A. flavipes* (Bainier and Sartory)  
     Thom and Church  
*S. flavipes* Bainier and Sartory  
*A. flavo-viridescens* Hanzawa  
*A. flavus* Link  
*A. flavus* forma *maydis* Ciferri  
*A. fontynonti* Gueguen  
*S. fuliginosa* Bainier  
*A. fuliginosus* Peck  
*S. fulva* (Mont.) Saccardo  
*A. fulvus* Montagne

## INDEX OF SPECIES.

- A. fumaricus* Wehmer  
*A. fumigatoides* Bainier and Sartory  
*A. fumigatus* Fresenius  
*A. fumigatus* var. *alpha*  
                                 Sion and Alexandrescu  
*A. fumigatus* var. *minimus* Sartory  
*A. fumigatus* var. *tumescens*  
   Blumentritt  
*A. fungoides* Greco  
*S. fusca* Bainier  
*A. fusco-cinereus* Ellis and Morgan  
*A. fuscus* Amons  
*A. fuscus* Bonorden  
*A. fuscus* Schiemann  
*A. galeritus* Blochwitz  
*A. giganteus* Wehmer  
*A. gigante-sulphureus* Saito  
*A. gigas* Spegazzini  
*S. glauca* Bainier  
*A. glaucoides* Spring  
*A. glaucus* Link  
*A. glaucus* var. *albida* Spegazzini  
*A. glaucus* var. *clavatus* Chevallier  
*A. glaucus* var. *minimus* Hanzawa  
*A. glaucus* var. *oblongisporus*  
   Ellis and Everhart  
*A. glaucus* var. *olivascens* Saccardo  
*A. glaucus* var. *repens* Corda  
*A. glaucus* var. *subolivaceus* Ferraris  
*A. globosus* Jensen  
*A. globosus* Link  
*A. godfrini* Sartory and Roederer  
*A. gracilis* Bainier  
*A. gratioli* Sartory  
*A. griseus* Link  
*A. gymnosardae* Yukawa  
*A. hageni* Hallier  
*A. halophilus*  
                                 Sartory, Sartory and Meyer  
*S. helva* Bainier  
*A. hennebergi* Blochwitz  
*A. herbariorum* (Wiggers) Winter  
*A. herbariorum* ser. *major* var. *violaceus*  
                                 (Mangin) Thom & Church  
*A. heterocephalus* Spring  
*A. hispidulus* Sprengel  
*S. hortai* Langeron  
*A. humicola* Chaudhari and Sachar  
*A. inorassatus* Spring  
*S. insueta* Bainier  
*A. insuetus* (Bainier) Thom & Church  
*Aspergillopsis intermedia* Spegazzini  
*A. itaconicus* Kinoshita  
*S. italica* Saccardo  
*A. japonicus* Saito  
*A. jeanselmei* Ota  
*A. keratitis* Ball  
*A. koningi* Oudemans  
*A. laneus* Link  
*A. lepidophyton* Wehmer  
*A. lignieresi* Costantin and Lucet  
*A. luchuenensis* Inui  
*S. lutea* Bainier  
*S. lutea* Van Tieghem  
*A. luteo-niger* (Lutz)  
   Thom and Church  
*S. luteo-nigra* Lutz  
*A. luteo-virescens* Blochwitz  
*A. lutescens* Bainier  
*A. macrosporus* Bonorden  
*A. malignus* Lindt  
*A. maximus* Link  
*A. maydis* Quevedo  
*A. medius* Meissner  
*A. melleus* Yukawa  
*A. mencleri* Sartory and Flament  
*A. michelii* Preuss  
*A. microsporus* Boke  
*A. minimus* Wehmer  
*S. minor* Bainier  
*A. minutus* Abbot  
*A. mollis* Bainier and Sartory  
*A. mollis* Berkeley  
*A. mucroides* Corda  
*A. mucoroides* Cooke  
*A. mulleri* Berkeley  
*A. mutabilis* Bainier and Sartory  
*A. mycobanche* Link  
*A. nanus* Montagne  
*A. nanus* Oudemans  
*A. nidulans* (Eidam) Winter  
*S. nidulans* Eidam  
*Diplostephanus nidulans* (Eidam)  
   Langeron  
*S. nidulans* forme *cesarii* Pinoy  
*S. nidulans* var. *nicollei* Pinoy  
*A. niger* Van Tieghem  
*Aspergillopsis nigra* (Van Tieghem)  
   Spegazzini  
*S. nigra* Van Tieghem  
*A. nigrescens* Robin  
*A. nigricans* Wreden  
*A. nigriceps* Berkeley and Curtis  
*A. niveo-candidus* Lindau  
*A. niveus* Blochwitz  
*A. niveus* Micheli  
*A. nolting* Hallier  
*A. novus*  
*A. oblongisporus* Ellis and Everhart  
*S. ochracea* Bainier  
*S. ochracea* Delacroix  
*A. ochraceo-ruber* Saccardo  
*A. ochraceus* Wilhelm  
*A. ochraceus* var. *microspora*  
   Tiraboschi  
*S. ochroleuca* Spegazzini  
*A. okazaki* Okazaki  
*S. olivacea* Van Tieghem  
*A. olivaceus* Delacroix  
*A. olivaceus* Preuss

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- A. oosporus* Wallroth  
*A. oryzae* (Ahlburg) Colm  
*A. ostianus* Wehmer  
*A. ovalispermus* Link  
*A. parasiticus* Speare  
*A. penicillatus* Greville  
*A. penicillatus* Link  
*A. penicilloides* Spegazzini  
*A. penicillopsis* (Hennings) Raciborski  
*A. periconioides* Saccardo  
*A. perniciosus* Inui  
*A. phaeocephalus* Durieu & Montagne  
*A. phoenicis* (Corda) Thom  
*S. phoenicis* (Corda)  
 Patouillard and Delacroix  
*Ustilago phoenicis* Corda  
*A. pictor* Blanchard  
*S. polychroma* Ferraris  
*A. polychromus* DeMello  
*A. polymorphus* Moquin-Tandon  
*A. pouchetii* Montagne  
*S. prasina* Bainier  
*S. pseudocaroonaria* Bainier  
*A. pseudo-clavatus* Purjewicz  
*A. pseudo-flava* (Saito) Saccardo  
*A. pseudo-flavus* Saito  
*A. pseudo-glaucus* Blochwitz  
*S. pseudo-nidulans* Vuillemin  
*S. pseudo-nigra* Costantin and Lucet  
*S. pulchella* Spegazzini  
*Aspergillopsis pulchella* Spegazzini  
*A. pulchellus* (Speg.)  
 Thom and Church  
*A. pulmonum hominis* Welcker  
*A. pulverulentus* (McAlpine) Thom  
*S. pulverulenta* McAlpine  
*A. pulvinatus* Berkeley and Curtis  
*S. purpurea* Van Tieghem  
*A. purpureo-fuscus* Fries  
*A. purpureo-fuscus* Schweinitz  
*A. purpureus* Haller  
*A. pusillus* Massee  
*A. quadrifidus* Link  
*S. quercina* Bainier  
*A. quercinus* (Bainier)  
 Thom and Church  
*A. quininae* Heim  
*A. racemosa* Persoon  
*A. ramosissimus* Haller  
*A. ramosus* Hallier  
*A. rehmii* Zukai  
*A. repandus* Bainier and Sartory  
*A. repens* (Corda) Saccardo  
*A. restrictus* Smith  
*A. restrictus* var. *B* Smith  
*A. roseus* Batsch  
*A. rubens* Green  
*A. ruber* (Spieckermann and Bremer)  
 Thom and Church  
*A. rufescens* Berlese  
*A. sachari* Chaudhari and Sachar  
*A. sartoryi* Sydow  
*A. scheelei* Bainier and Sartory  
*A. schiemanni* (Schiemann) Thom  
*A. sclerotiorum* Huber  
*A. sejunctus* Bainier and Sartory  
*A. siebenmanni* Costantin and Lucet  
*A. simplex* Persoon  
*A. spadix* Amons  
*A. sphaerospermus* Corda  
*A. spiralis* Grove  
*A. spirius* Amons  
*S. spuria* Schroter  
*A. stercoreus* Saccardo  
*A. sterigmatophorus* Saccardo  
*A. strychni* Lindau  
*A. subfuscus* Johan-Olsen  
*A. subgriseus* Peck  
*S. sulphurea* Fresenius  
*A. sulphureus* (Fresenius)  
 Thom and Church  
*A. sydowi* (Bainier and Sartory)  
 Thom and Church  
*S. sydowi* Bainier and Sartory  
*A. syncephalis* Gueguen  
*S. szurakiana* Moesz  
*A. tamarii* Kita  
*A. terreus* Thom and Church  
*A. terricola* Marchal  
*A. terricola* var. *americana* Marchal  
*A. tokelau* Wehmer  
*S. tunetana* Langeron  
*A. umbrinus* Patterson  
*A. umbrosus* Bainier and Sartory  
*S. unguis* Emile-Weil and Gaudin  
*S. usta* Bainier  
*A. ustilago* Beck  
*A. ustus* (Bainier) Thom and Church  
*S. varia* Bainier  
*A. varians* Wehmer  
*A. variabilis* Gasperini  
*S. veneta* Massalongo  
*A. venetus* (Massal.) Lindau  
*A. versicolor* (Vuillemin) Tiraboschi  
*S. versicolor* Vuillemin  
*A. violaceo-fuscus* Gasperini  
*A. virens* Link  
*A. viridis*  
*A. virido-griseus* Costantin & Lucet  
*S. vitellina* Ridley  
*S. welwitschiae* (Bresadola) Hennings  
*A. wehmeri* Costantin and Lucet  
*A. wentii* Wehmer  
*A. westendorpii* Saccardo & Marchal

Notes on the *Puccinelliae* of New Zealand.

By H. H. ALLAN and P. JANSEN.

[Read before the Wellington Philosophical Society, October 12, 1938; received by the Editor, March 7, 1939; issued separately, September, 1939.]

PARLATORE (*Fl. Ital.*, 1, 1848, 366) when erecting the genus *Puccinellia* described four species, of which *P. distans*, based on *Poa distans* L., is commonly accepted as the type. Cheeseman (*Man. N.Z. Flora*, ed. 2, 1925, p. 202) places the New Zealand species under the synonym *Atropis* Rupr. Here we make the necessary new combinations, add descriptions of new species and varieties, and list the species known to occur as introduced plants. We have examined the material to be found in the following herbaria: Royal Botanic Gardens, Kew; The Memorial Museum, Auckland; The Dominion Museum, Wellington; the Plant Research Bureau, Wellington. The collections are too incomplete, and the specimens for the most part (owing to the special difficulties of preserving good fruiting material) too imperfect for a thorough revision to be made at present. It is also very desirable that the Australian species should receive fuller attention and comparison with New Zealand ones. However, the present paper should prove a useful preliminary to detailed studies:

1. *P. stricta* (Hook. f.). Blom, *Acta horti gotoburgensis*, V, 1929, p. 89.

*Glyceria stricta* Hook. f., *Flora Nov.-Zel.*, 1, 1855, 304.

*Atropis stricta* Hack. ex Cheeseman, *Man. N.Z. Flora*, 1906, 202; non *Glyceria striata* Buckl. *Proc. Acad. Sci. Philad.*, 1863, 95; non *Puccinellia stricta* Keng., *Sinensia*, 4 (11), 1934, 321.

Hooker in his original account cited specimens collected by Raoul at Akaroa, South Island, New Zealand, and remarked: "Mr. Gunn has also sent me specimens of this plant from Tasmania; they are much larger than the New Zealand ones, but not otherwise different." There are, however, a number of points of difference. An examination of the specimens in the herbarium of the Royal Botanic Gardens, Kew, showed that Gunn's specimens are more in accord with the original description than Raoul's and must be taken as the type. The Director of the Royal Botanic Gardens, Kew, has kindly informed us that both Dr. T. A. Sprague and Mr. C. E. Hubbard have closely examined the material and fully concur in this view. To the latter we are indebted for the following comparative table.

<i>Raoul's Specimens.</i>	<i>Hooker's Description.</i>	<i>Gunn's Specimens.</i>
Culms 4-10 in. high; slender.	1½-2 ft. high; stout	8-22 in. high; relatively stout.
Sheaths rather short, not swollen.	long; rather swollen.	long; rather swollen.
Lamina short, 1½-3 in.	short, 2-4 in.	3-7 in.
Panicle 1½-4 in. long.	4-6 in. long.	4-7 in. long.
Spikelets rather loose; rather dull.	rather crowded; almost shining.	rather crowded; almost shining.
Florets 6-8.	6-14	6-10.

An important difference between all New Zealand and Australian specimens that we have seen is that the lemmas of the New Zealand forms are always relatively broader. Gunn's specimens are, therefore, accepted as the type. The species in Australia is polymorphic, but our material is insufficient for a full varietal treatment. So far none of the Australian forms have been met with in New Zealand.

Cheeseman (*Man. N.Z. Flora*, 1906, p. 915) published the variety *suborbicularis* Hack., from the manuscript name of Hackel, based on specimens collected near Oamaru by Petrie: "Flowering glume much broader than in the type, in outline almost orbicular. Leaves weaker and thinner." In the second edition of his *Manual* (1925, p. 202) Cheeseman adds to the variety specimens collected by Laing on Banks Peninsula. An examination of the populations in both localities shows that they present no significant differences from the New Zealand forms in general, and we adopt the varietal name, *suborbicularis* for the whole New Zealand group in contrast with the Tasmanian type. While further study will probably reveal greater polymorphy, our material does not allow us to do more than separate the New Zealand variety into two forms, both of widespread distribution.

f. *luxurians* Allan et Jansen. Culmi 3-4 dm. longi, laminae usque ad 15 cm. longae; paniculae, statu maturo, ramulis aliquanto longis.

f. *pumila* Allan et Jansen. Culmi  $\pm$  1 dm. longi, laminae breviores, paniculae subspiciformibus, ramulis brevibus, spiculae paucae.

It should be pointed out that in the illustration of Buchanan (*Man. Indig. Grasses N.Z.*, 1880, t., XLI) the spikelet details of A (*Glyceria stricta*) and B (*Catabrosa antarctica*) have been transposed.

2. **P. antipoda** (Petrie) Allan et Jansen *comb. nov.*

*Atropis antipoda* Petrie, *Subantarct. Is. N.Z.*, 1909, p. 480.

3. **P. novae-zealandiae** (Petrie) Allan et Jansen *comb. nov.*

*Poa walkeri* Kirk, *Trans. N.Z. Inst.*, vol. 17, 1885, p. 224 (*nomen nudum*).

*Glyceria novae-zealandiae* Petrie, *Trans. N.Z. Inst.*, vol. 33, 1901, p. 329.

*Atropis novae-zealandiae* Hack. ex Cheesem., *Man. N.Z. Flora*, 1906, p. 915.

*A. walkeri* Cheesem., *Man. N.Z. Flora*, 1925, p. 203.

4. **P. chathamica** (Cheesem.) Allan et Jansen *comb. nov.*

*Atropis chathamica* Cheesem., *Man. N.Z. Flora*, 1925, p. 203.

Petrie based his *A. antipoda* on specimens collected by Aston on Antipodes Island, but did not discuss its affinities. Cheeseman added specimens from Auckland Islands and remarked, "closely allied to *A. walkeri*, but appears to differ in the smaller size and more slender habit, 2-noded culm, and in the larger number of florets in the spikelets." Cheeseman based his *A. chathamica* on specimens collected by Cox in Chatham Islands, and remarked, "This appears to be a distinct species, easily recognized by its stout, loosely tufted habit, long, narrow panicle, and narrow, many-flowered spikelets." Our examination leads us to consider it highly probable that a thorough analysis of the populations would lead to *P. antipoda*, *P. chathamica* and *P. novae-zealandiae* being united into one species. The differences relied on by Cheeseman are inconstant, as is seen in his own specimens.

His description of the glumes of *P. chathamica*: "two outer glumes unequal, the longer one about  $\frac{1}{2}$  the length of the spikelet, lanceolate, 3-nerved; the shorter broader, 1-nerved," as against *P. novae-zealandiae*: "Two outer glumes slightly unequal, about  $\frac{1}{2}$  the length of the whole spikelet; lower narrow, lanceolate, acute, 1-nerved, sometimes with a short lateral nerve on each side; upper broader and more obtuse, 3-nerved" is particularly faulty. The relative lengths and number of nerves of the glumes are variable, often in the same panicle. The lemma of *P. chathamica* is 5- not 3-nerved as stated, thus removing another difference. The central nerve in *P. chathamica* is distinctly excurrent, so that the three groups may be distinguished as follows:

1. Median lemma-nerve not excurrent .. ..	<i>novae-zealandiae</i>
Median lemma-nerve excurrent .. ..	2
2. Plant small, slender .. ..	<i>antipoda</i>
Plant, tall, stouter .. ..	<i>chathamica</i>

*P. antipoda* appears to be confined to the Subantarctic Islands, and *P. chathamica* has hitherto been considered endemic to Chatham Islands, but certain immature specimens recently collected by Messrs. J. Scott-Thomson and G. Simpson near Dunedin appear referable to *P. chathamica* rather than to *P. novae-zealandiae*. This last is known from a number of stations on the eastern and southern coasts of Otago, and from Stewart Island. Certain imperfect specimens collected near Napier also appear to belong to *P. novae-zealandiae*. Obviously, the whole group needs much further work.

##### 5. *P. scott-thomsonii* n.sp.

Dense caespitosa. Culmi erecti, ad 30–40 cm. alti (e vagina superiore) exserti, basi innovationibus intra vaginalibus brevibus paucinodis circumdati. Folia inferiora vagina lata laxa hyalina, lamina stricta, 6–10 cm. longa, 1–1.5 mm. lata, anguste lineari, statu sicco convoluta setacea, ligula 1–1.5 mm. longa, hyalina, rotundata; folia caulina 3 vel 4, sursum gradatim breviora, suprema lamina 2.5–3 cm. longa (quam vagina brevior), 2 mm. lata, conduplicata. Panicula pyramidata, 6–8 cm. alta, rhachi stricta, angulata, scabra, semiverticillis distantibus sursum ramis gradatim brevioribus, plerumque e ramis 3 compositis ante anthesin erectis, sub anthesi erecto-patentibus vel patulis, non reflexis, spiculis subsessilibus vel breviter pedicellatis, 5–6 mm. longis, oblongo-linearibus, 4–5 floris. Glumae valde inaequales, inferior ovalis, 1–1.2 mm. longa, uninervia, superior ovata, acuta, distincte trinervia, 2.5 mm. longa; glumella cymbiformis, apice rotundata, a latere visa acuta, 2.5 mm. longa, margine hyalino angusto, rubro tincta, basin versus breviter pilosa, ceterum glabra, nervis medianis 3 distinctis et nervis lateralibus 2 debilibus, costa apicem non attingente; palea quam glumella brevior, marginibus ciliatis; stamina filamentis brevibus, antheris ad 1 mm. longis; styli 2 ad basin divisi. Caryopsis linearis, hilo parvo ovato.

Typus in herb. Jansen et Wachter: Nova Zelandia, Waikouaiti, m. Decembrianni, 1935 (coll.) J. Scott-Thomson, sine numero. Co-type in herb. Plant Research Bureau, Wellington.

This species is abundant in salt marshes between Waikouaiti and Dunedin, South Island. It has also been collected near Napier, North Island, and probably occurs elsewhere, being passed over as *P. distans*. It has also been erroneously referred to as *P. festuciformis* Parl. (Allan: *Introduction to Grasses of N.Z.*, 1936, p. 41). A form with the spikelets distinctly reddish-tinged is common.

6. *P. fasciculata* (Torr.) Bicknell, *Bull. Torrey Bot. Club*, 35, 1908, 197.

*Poa fasciculata* Torr., *Fl. U.S.*, I, 1824, p. 107.

This species occurs in salt marshes from Nova Scotia to Delaware, and inland in Utah. It also occurs in Europe. The New Zealand forms, hitherto passed over as *P. distans*, are distinct and fall into two varieties.

var. *novazelandica* nov.

Differt a typo atlantico: culmis ad 70 cm. altis, panicula ad 20 cm. longa, angusta, semiverticillis ad 4 cm. distantibus, ramis brevioribus, nervis obsoletis.

Typus in herb. Jansen et Wachter.

Fréquent, in company with *P. scott-thomsonii*, between Waikouaiti and Dunedin. A form with reddish-tinged spikelets is occasional.

var. *caespitosa*. nov.

Caespites densos durosque formans, foliis brevibus angustis involutis, culmis 15–20 cm. altis, panicula 4–5 cm. longa, spicatum contracta.

Typus in herb. Jansen et Wachter.

Originally collected and distributed without name by Petrie from Chatto Creek, Central Otago, 1911. Occasional in "alkali" patches in Central Otago. This variety is very closely allied to South African forms.

7. *P. macquariensis* (Cheesem.) Allan et Jansen.

*Triodia macquariensis* Cheesem., *Vasc. Flora Macquarie Is.*, 1910, p. 34 (*Sc. Rep. Austral. Antarot. Exped.*, 7, 3).

Cheeseman remarks: "a puzzling plant to place. It differs from *Poa* principally in the flowering glumes being rounded on the back, and minutely 3-toothed (or irregularly erose) at the tip. It agrees with *Atropis* in the flowering glumes being rounded on the back, but differs in habit and in the 3-toothed tip of the flowering glume. Although it is not a typical *Triodia*, it must be kept in the vicinity of the New Zealand *T. australis*." The habit is given as "dense caespitosum" and the habitat as "a common coastal grass, found in crevices in bare rock or on the cliffs."

We have seen but little material (that available to Cheeseman), but it is quite certain that the plant does not belong to *Triodia*. The resemblances to *T. australis*, which has the flowering glume with

the mid and lateral nerves prolonged into definite awn-points, are superficial only. In *P. macquariensis* the nerves of the flowering glumes do not attain to the hyaline margin, which becomes irregularly erose when over-mature.

*P. distans* (L.) Parl. This was recorded for New Zealand by Cheeseman (*Man. N.Z. Flora*, 1906, p. 915) as "naturalized in several localities." It is known to us from only one collection, made by Mr. J. Scott-Thomson at Tomahawk Lagoon, near Dunedin. As pointed out above, both *P. scott-thomsonii* and *P. fasciculata* have been confused with it.

*P. rupestris* (With.) Fern. et Weath. This was recorded for New Zealand by A. Wall (*Trans. N.Z. Inst.*, vol. 53, 1921, p. 428) under the synonym *Glyceria procumbens*, for Tomahawk Lagoon, near Dunedin. It still flourishes there, and has spread to other salt marshes in the neighbourhood of Dunedin.

## Notes on New Zealand Floristic Botany.

INCLUDING DESCRIPTIONS OF NEW SPECIES, ETC.—No. 7.

By H. H. ALLAN, Plant Research Bureau.

[Read before the Wellington Philosophical Society, October 12, 1938; received by the Editor, March 7, 1939; issued separately, September, 1939.]

### I. TAXONOMIC.

#### 1. *Aciphylla leighii* n.sp.

Affinis *A. dobsoni*, sed differt statu minore, foliis vix rigidis, non pungentibus, umbellis vix capitatis.

Herb, forming patches up to 2 m. diam. Rosettes in flower, c. 6 cm. tall, with spread of c. 7 cm. Tap root stout c. 6 mm. diam., remaining so for at least 6 cm., with numerous descending lateral rootlets. Leaves c. 5 cm. long, standing at c. 45° with horizontal. Sheathing bases c. 3-5 cm. long, white with thin hyaline margins, becoming yellowish-green on back towards leaflets; concave, thin below, thickening upwards and curving outwards, striate and shallowly grooved on back; c. 1 cm. wide at base, narrowing to c. 6 mm. at base of leaflets; thickened upper portion spongy, with copious milky juice from dorsal vessels; leaflets 3, diverging, triangular in projection, the two lateral facing each other, the central slightly longer. Segments c. 1-6 cm. long, c. 1 mm. thick at midrib, c. 4 mm. wide, shallowly channelled above; dark green, margins cartilaginous, about linear-oblong, convex on back, distinctly veined, cross veinlets evident, slightly constricting margins; apices yellowish, blunt to retuse, with short mucro.

Peduncle central, c. 5 cm. long, striate, surmounted in male by rather dense compound umbel c. 4 cm. across; primary rays 3 to 4, with general involucre of leaf-like bracts; rays c. 4 cm. long, unequal, diverging, somewhat flattened, thickened slightly upwards, ending in umbels, or again branched and enclosed in sheaths of bracts; secondary umbels c. 2-5 cm. across, with leaflike involucre bracts, or with only central leaflet developed, or reduced to sheaths; rays 7 to 10, c. 6 mm. long, ending in 3 segments with finely acicular tips; bracteoles scalelike. Final umbellules of c. 20 flowers, the filiform bracteoles exceeding the flowers.

Sepals greenish, incurved, linear, acute, enlarging after petal fall to 2 mm. long, concave, narrowed to short claw; stamens exserted at anthesis, with filaments up to 3 mm. long, disc yellowish. Female plants not seen.

Mount Milne, Darran Range, Western Otago (Fiord Bot. Dist.) at c. 1980 m. D. Leigh! Type at Herbarium, Plant Research Bureau, Wellington.

Mr. Leigh provides the following interesting note on his discovery of this notable addition to the genus *Aciphylla*, specimens of which are now growing in the scree garden of Mr. J. Scott-Thomson: "The Darran Range occupies nearly all the west coast territory of Otago, and is isolated from all neighbouring alpine country principally by the deeply cut valley of the Hollyford River. The

northern section is connected with the Central Darrans by a narrow, precipitous barrier of peaked ridges coming off Mount Madeline and bearing due south to Mount Underwood between Tutoko River and the Lower Hollyford. It was on these intervening peaks that I collected this distinct species of *Aciphylla* at an altitude of 6,500 feet, beneath the summit rocks of the peak which the late Samuel Turner called Mount Milne. Growing on stabilized scree terraces and forming circular patches sometimes six feet in diameter, this *Aciphylla* provided a unique appearance. The habitat is very exposed, being directly opposite the massive ice-face of Mount Tutoko, and above a branch of the Madeline Ice Plateau. There were no signs of this plant on the north-east face of Tutoko, and I am of the opinion that the snowfield on Mount Underwood would prevent its dissemination over the extensive central Darrans. The plant did not occur anywhere below the Madeline Ice Plateau."

## 2. *Coprosma*.

A remarkable "sporting" *Coprosma* (plate 23) has been observed on Mayor Island, Bay of Plenty, by Misses L. B. Moore and J. Wakelin. The following account has been drawn up from notes and specimens kindly sent me.

The species known to occur on the island are: *C. australis*, *C. lucida*, *C. macrocarpa* (the North Auckland form), *C. repens* (*baueri*) and *C. robusta*. The "*C. robusta* var. *angustata* Kirk?" listed by Allan and Dalrymple (1926, p. 36) may have been gathered from one of the sporting plants. These were noted by the discoverers on the south-east slopes in second-growth scrub of *Leptospermum*, with *Knightia excelsa*, *Suttonia australis* and other species, and on the scrub margins. They were about as plentiful as *C. robusta*. They reached 3 m. in height, and were always in a sufficiently open station to be leafy almost to the ground, at least on one side.

The sport is characterized by bearing branches carrying leaves of two forms and sizes. Some branches have large leaves, somewhat of *robusta* size, shape and texture, but slightly more coriaceous and lustrous, and usually with a mucronate tip. Average dimensions are 8 cm. by 3.5 cm. Other branches bore leaves similar in texture, but much smaller and narrower, rather like *C. lucida* var. *angustifolia* Cheeseman. Average dimensions are 4 cm. by 1.25 cm. "Specimens like that shown in the photograph were never difficult to find, but often the two parts of the plant separate out at one of the lower forks, so that at a glance one would think that there were two distinct plants. Though the big-leaved form is plentiful, we found no case where a plant had nothing but small leaves. Both parts of the plant fruit, but the smaller-leaved part more abundantly. Fruit, though green, was heavy and conspicuous. The flowers were often ♂, with persistent perianths." Unfortunately, no ripe fruit was obtained, so that progeny tests have not yet been carried out.

## 3. *Coriaria kingiana* Colenso.

Although this name was effectively and validly published by Colenso (1844, p. 20) it has been ignored by all subsequent writers. He states of it, "an elegant procumbent plant with undulated ovate-acuminate leaves. It seldom rises above two feet in height, and is

mostly found quite prostrate, and very abundant." Petrié (1921, p. 368) described his var. *undulata* of *C. thymifolia* as "a typo differt foliis tenuioribus ac secundum margines emorso-undulatis, floribus minoribus," and appropriately remarked that the edges of the leaves look "as if a small insect had made a regular series of closely-placed bites all round." The taxonomy of *Coriaria* is in an extremely unsatisfactory state, but there is now general agreement that the true *C. thymifolia* does not occur in New Zealand. Kirk's name *C. lurida* is often used to apply to all the New Zealand "*thymifolia*" forms, though he himself (1899, p. 98) specially separated out his *lurida* from the rest of the complex. Colenso's name has priority for this group, if it is not to be retained for the special undulate variety described. But the whole *Coriaria* complex needs fresh investigation. It is now known that undulate form also occurs in the "*ruscifolia*" or "*sarmentosa*" group, in the "*parvifolia*" group, and is transferred by hybridism to the "*arborea*" group (cf. Allan, 1930, p. 446).

#### 4. *Dracophyllum rosmarinifolium* (Forst. f.) R. Br.

This is based on specimens collected by Forster at Dusky Sound. Hooker (1864, p. 183) included under it what is now known as *D. pronum* W. R. Oliver, and described as new *D. uniflorum*, with pungent leaves, from specimens collected in various parts of South Island. Oliver (1928, p. 689) rightly separated *Epacris rosmarinifolia* Forst. f. from *D. pronum*, but treated *D. uniflorum* as a synonym of *D. rosmarinifolium*. His action was largely based on the views of Professor A. Wall, whom he quoted as follows: "... Forster's type. There is one small twig only with no fruit or flower . . . The only other specimen there [British Museum] is one of Kirk's from Amuri, which is exactly the same plant as Forster's. It was plain to me at once that Forster's plant (and Kirk's) is simply what we now call *D. uniflorum* . . . Dr. Rendle agreed with me that they, specimens of *D. uniflorum*, perfectly match the *D. rosmarinifolium* of Forster." Oliver added, "as pointed out by Hooker the characters by which this species may be recognized are the short pungent leaves and the large solitary flowers."

My examination of the material at the British Museum and at Kew lead me to a somewhat different conclusion. The leaves in the type specimen of *Epacris rosmarinifolia* are from 15 to 25 mm. long, slightly over 1 mm. wide, the upper third of the blade trigonous, narrowed rather abruptly to the tip, the lower part channelled; the sheaths not shouldered. Taking Travers's Wairau mountain specimens as the type of *D. uniflorum*, we find: leaves 30 to 40 mm. long, hardly 1 mm. wide, the upper half trigonous, narrowed gradually to the acute apex, very shallowly channelled below; sheaths abruptly shouldered. Kirk's Amuri specimens agree very well with *D. uniflorum*. Oliver (*loc. cit.*, p. 690), however, recognizes that these differences exist, mentioning two forms, "apparently not depending on habitat": (a) leaves less than 1 mm. wide, up to 35 or 40 mm. long—"Tararua Ranges, Nelson, and Canterbury"; (b) leaves up to 25 mm. long and 1.5 mm. broad—"Otago (Mount Barber)." He adds, "Forster's type agrees with this broad-leaved form."

That *D. rosmarinifolium* and *D. uniflorum* are different is clear. The evidence is all against either being a "habitat form" of the other. Whether *D. uniflorum* should be accepted as a species or given the status of a variety of *D. rosmarinifolium* cannot be decided till a full comparison of flower and fruit characters has been made. Dr. Oliver has kindly given me specimens of the Mount Barber plant. These have rather stouter leaves than those of Forster's type, but otherwise have the same characteristics.

#### 5. *Halorrhagis colensoi* Skottsberg.

This species was described by Skottsberg (1922, pp. 152, 153, 156) from a collection by Colenso, present among a set of *H. erecta* in the Kew Herbarium. But though figured and validly described, it was not referred to by Cheeseman (1925). It was rediscovered by Mr. T. Latta on Mount Oporae, near Weber (Ruahine-Cook Bot. Dist.) and specimens were sent to Professor Skottsberg, who has supplied the following fuller diagnosis:

"*Suffrutex laevis glaberrimus, H. masatierranae* Skottsberg. similimus. Folia ovata usque lanceolata, acuta, basi cuneata, lamina 10–15 mm. et ultra, longa et 6–8 mm. lata, argute serrata dentibus utrinque 5–7, petiolo 3–4 mm. longo suffulta. Flores subsessiles. Achaenia ovoideo-conica, 2.9–3.3 mm. longa (sepalis inclusis) et 1.7–2 mm. diam., tetragona, laevia, sed in parte dimidia inferiore transverse tuberculato-rugoso, exalata vel alis 4 angustis triangulatis parvis nec non humilibus infra medium positis ornata. Cetera ignota. Hab. *Novae Zelandiae* ins. bor. (Colenso in herb. Kew); in collibus Puketoi dietis, commun. H. H. Allan.

As pointed out (*l.c.*) *H. colensoi* is very close to *H. masatierrana*, from which it differs mainly in the smaller leaves and fruits, which, in the latter, lack the tubercles and are perfectly smooth; but it should be noted that of *H. masafuerana* (*l.c.*, p. 156) I have forms with or without tubercles. Petals, stamens and stigmas will probably show some differences, and in any case I do not find it possible to refer *H. colensoi* to *masatierrana*, or to any other species I know of. The close affinity between the *Halorrhagis* species of New Zealand and Juan Fernandez is of considerable interest. We have, in fact, two pairs of vicarious species: *H. colensoi*—*H. masatierrana* and *H. erecta*—*H. asperrima*, whereas no *Halorrhagis* has ever been found in South America."

#### 6. *Hebe raoulii* (Hook. f.) Ckn. et Allan var. *maccaskillii* nov.

A typo differt ramis gracilioribus, elongatis; foliis minus coriaceis, interdum vix dentatis, floribus manifeste pedicellatis.

Weka Pass, Canterbury, on limestone, L. W. McCaskill! White Rock, on limestone, R. M. Laing! Type in Herbarium, Plant Research Bureau, Wellington.

This graceful plant is easily distinguished from the type by the slender, rambling habit, the less coriaceous leaves with few or no teeth, the floral ones suborbicular, the longer racemes, the flowers definitely stalked. It appears to be confined to limestone. An interesting feature is the presence on many flowers of a scale-like fifth sepal. In exposed places the stems lie flat on the rock, while amongst

*Sophora prostrata* and other shrubs they become semi-lianoid. I am indebted to Mr. McCaskill for a large suite of specimens and for field notes on its habit and occurrences.

7. *Hebe scott-thomsonii* n.sp.

*H. traversii* et *H. brachysiphon affinis*, sed sepala 1-1.5 mm. longa; corollae tubus brevis; sursum aliquatenus dilatatus, sepala vix aequans; capsula minute pubescens, 5-6 mm. longa, sepalis 3-4-plo longior.

South and North Otago Bot. Dists. By streams in tussock grassland: Deep Stream, Lammerlaw Hills, Rock and Pillar Range, Macrae's Hill, Upper Waikouaiti River, Mount Hyde, Stoneburn. Type in Herbarium, Plant Research Bureau, Wellington.

Shrub up to 1 m. tall; leaves oblong-obovate, rather abruptly acute, to narrow-oblong subacute, up to 2.5 cm. long and 0.8 cm. broad, slightly concave, drying yellowish brown; racemes slender, c. 4 to 5 cm. long, elongating in fruit; pedicels c. 2 mm. long, pubescent; bracts ovate to linear, variable in size; calyx segments ovate, obtuse or occasionally subacute, ciliolate; corolla tube very short, widening upwards, hardly attaining the apices of the calyx lobes; corolla lobes broadly obovate to subrotund, c. 2 mm. long and broad; capsules finely pubescent, 5 to 6 mm. long, c. 3 to 4 times length of calyx.

The "*traversii*" complex has long been a difficulty to students. Summerhayes (1927, p. 395) established the type as being the plant with the corolla tube two to five times the length of the calyx. From the short-tubed forms he selected the species figured by Hooker in *Bot. Mag.*, t. 6390, and gave it the name of *H. brachysiphon*. He includes a specimen gathered by Petrie at Lake Wakatipu (South Otago Bot. Dist.), the other localities cited being in the Sounds-Nelson, North-eastern and Eastern Bot. Districts. *H. traversii* appears to be confined to the Eastern District. The three species thus provide an interesting example of geographical distribution. Possibly all should be united as varieties of *H. traversii* in a wide sense, but other members of the complex need examination before a full revision can be made. The account of cytology within the complex promised by Frankel and Hair (1937, p. 685) should present important data in this connection. The following synopsis may be useful:

*H. traversii*—calyx 1.5 mm. long; corolla tube slender, cylindric, 2-5 times length of calyx; capsule 5 mm. long, 3-4 times length of calyx.

*H. brachysiphon*—calyx 2-3 mm. long; corolla tube rather broad, widening upwards, equalling or up to twice length of calyx; capsule 5-6 mm. long, 2-2½ times the length of calyx.

*H. scott-thomsonii*—calyx 1-1.5 mm. long; corolla tube rather broad, widening somewhat upwards, hardly equalling calyx; capsule 5-6 mm. long, 3-4 times length of calyx. This species is further referred to by Simpson and Scott-Thomson (1938, p. 435).

### 8. *Nertera balfouriana* Ckn.

The flowers have not hitherto been described. The following is drawn up from specimens collected on Mount Mistake, Lake Tekapo, in early January. Flowers markedly protogynous. Calyx truncate, obsolescent. Corolla 4-lobed; tube 2.25–3 mm. long, glabrous, funnelform; lobes bluntly triangular, reflexed, papillose on margin. Styles projecting beyond anthers, recurved, united in basal third. Stamens c. 5 mm. long, erect, often dehiscing before extending beyond corolla lobes and pollinating lower part of styles. Much pollen is caught on the corolla lobes.

### 9. *Veronica*.

The question here is whether *Veronica* in the strict sense, i.e. the subgenera *Veronicella* and *Euveronica*, is represented among indigenous plants. *Veronica* L. and *Hebe* Comm. are separated taxonomically as follows: *Veronica*—capsule dehiscing loculicidally, its walls and septum thin; herbs, the stems dying with the leaves. *Hebe*—capsule dehiscing septicidally, the thick septum splitting and each carpel opening distally by a median slit through the septal wall.

Hooker (1854, p. 190) under *Veronica* says: "Capsula compressa, bisulcata; carpellis dorso loculicide dehiscens, marginibus inflexis columnae placentiferae adhaerentibus v. ab ea septicide solutis; v. capsula septicida cum columna placentifera bipartibilis." In the loculicidal group he places *V. catarractae* and its allies.

In his later treatment Hooker (1864, p. 204) makes the same groups, separating them by (1) "capsule dorsally compressed, ovoid, turgid," and (2) "capsule laterally compressed, didymous." He gives, however, the capsule dehiscence as septicidal, and makes no reference to loculicidal dehiscence.

Cheeseman (1925, p. 776) states that the dehiscence is either septicidal or loculicidal. For his Division *Hebe* he gives, "Capsule turgid or dorsally compressed, the septum across the broadest diameter," and for his Division *Euveronica*, "Capsule laterally compressed, the septum across the narrowest diameter."

Pennell (1921) revived Commerson's genus *Hebe* on the grounds: (1) dehiscence of capsule septicidal, (2) leaves opposite throughout, (3) flowers always in axillary racemes, (4) all shrubs or trees, (5) distribution austral, "with its suggestion of genetic remoteness." He adds, "Moreover, *Hebe* has an exceedingly baffling tendency to form local races, a habit at contrast with that of the other '*Veronicas*'." The New Zealand species transferred are *H. salicifolia*, *H. blanda* and *H. elliptica*.

Cockayne and Allan (1926) accepted Pennell's action, and made the necessary new combinations. They, however, left Cheeseman's division *Euveronica* in *Veronica* sens. strict. Frankel and Hair (1937) examined the cytology of a number of New Zealand species. For *Hebe* they found the chromosome numbers: 20, 21, 40, 42, 60; and for *Veronica* 20, 21. They point out that in *Veronica* of the Northern Hemisphere the numbers 4, 8, multiples of 7, 9, 17 have been recorded. In *V. plebeia*, almost certainly an introduced plant

in its New Zealand occurrences, the number is also 17. They conclude: "From the cytological evidence it is apparent that the genus *Hebe* and the New Zealand *Veronicas* have closely allied chromosome complements which are equally far removed from those of the *Veronicas* endemic in the Northern Hemisphere. The austral distribution of the New Zealand *Veronicas* is a further characteristic linking them closer to the genus *Hebe* than to the Northern *Veronicas*. Therefore, although from the viewpoint of systematic convenience the New Zealand *Veronicas* belong to *Veronica*, according to the cytological evidence they must be grouped with *Hebe*. Here, then, we have probably the first example in which cytological findings are clearly contradictory to the systematic evidence."

In view of this I have examined the capsule dehiscence of those species of indigenous and introduced *Veronicas* of which suitable material was available. The ultimate result of the dehiscence is much the same in both. In *Hebe* the dehiscence is as described by Pennell (*loc. cit.*, p. 2): "the carpels part, thus splitting sagittally the septum, after which a distal median suture through the septal wall of each carpel permits the seeds to escape." In all the examples studied by me loculicidal stage commences early, before the septicidal dehiscence is complete. In *Veronica* (introduced species) the carpels split loculicidally, and later separate septicidally as noted by Hooker. The septicidal stage is usually long delayed and often imperfectly developed. Often the seeds are all shed before the septicidal split becomes evident. In the New Zealand species placed by Cheeseman in *Euveronica*, so far as I have been able to examine them, the dehiscence is essentially as in *Hebe*, though occasional capsules show a slight loculicidal split before the septicidal dehiscence has developed far. The septum is narrow, but the capsules are rather thick-walled and often turgid, and often not markedly didymous. The plants are small shrubs, or at least woody towards the bases, the stems not "dying with leaves." The group thus occupies a somewhat intermediate position, but is much closer to *Hebe* proper than *Euveronica*. If, as on most grounds seems preferable, *Hebe* is maintained as a separate genus, I agree with Frankel and Hair that the species of "*Veronica*" mentioned below should be transferred to *Hebe*.

It is very desirable that the remaining species, especially the herbaceous *V. canescens* (of which all my specimens are in young flower) be examined. *V. anagallis* is a true *Veronica*, but the evidence is all against it being indigenous. I, therefore, make the following new combinations:—

*Hebe bidwillii* (Hook.) Allan, comb. nov. *Veronica bidwillii* Hook., *Icon. Plant.*, 1848, t. 814.

*Hebe catarractae* (Forst. f.) Allan, comb. nov. *Veronica catarractae* Forst. f., *Flor. Ins. Aust. Prodr.*, 1786, p. 3.

*Hebe hookeriana* (Walp.) Allan, comb. nov. *Veronica hookeriana* Walp., *Rep.*, III, 1844, p. 341.

*Hebe linifolia* (Hook. f.) Allan, comb. nov. *Veronica linifolia* Hook. f., *Handb. N.Z. Flora*, 1864, p. 214.

*Hebe lyallii* (Hook. f.) Allan, comb. nov. *Veronica lyallii* Hook. f., *Fl. Nov.-Zel.*, 1, 1854, p. 196.

## II. PHYTOGEOGRAPHIC.

1. *Eleocharis gracilis* R. Br.

Mr. S. Blake, of the University of Queensland, who has kindly examined my specimens, finds that there is no specific difference between the *E. cunninghamii* Boeck. of New Zealand and the *E. gracilis* R. Br. of Australia. In both countries this species shows considerable habitat modifications, and the varietal names so far applied are of very doubtful status.

2. *Eleocharis pusilla* R. Br.

*E. acicularis* R. Br. was admitted to the New Zealand flora by Cheeseman (1925, p. 217) on immature specimens collected by Petrie at Lake Te Anau. He remarks: "Mr. C. B. Clarke, who has examined them, states that he is satisfied that they belong to the small group consisting of *E. acicularis* and a very few closely allied species, and most probably to *E. acicularis* itself." Mr. Blake places specimens sent by me under *E. pusilla* R. Br. It is represented in the herbarium of the Plant Research Bureau, Wellington, by specimens from: Lake Taupo (Volcanic Plateau Bot. Dist.) at water's edge, K. W. Allison!; Foxton (Ruahine-Cook Bot. Dist.) in damp sand hollows among dunes, V. D. Zotov!; Lake Tekapo (Eastern South Island Bot. Dist.), margins of tarns and moraine.

3. *Gaultheria colensoi* Hook. f.

This species was rightly revived by Burt and Hill (1935, p. 620). The stations given by them are: base of Mount Tongariro, near Lake Rotoaira, and Mount Ruapehu. Mr. N. Elder, who has devoted great attention to the Kaimanawa and adjacent ranges, found it on the Kaweka Range (at 900–1,200 m.), Black Birch Range (at 1,100 m.), and the southern Kaimanawas (at 1,370 m. and more). He finds that it usually occurs on rocky or shingly faces, flowering in December or January.

4. *Hebe acutiflora* (Benth.) Ckn.

Mr. K. W. Sexton has forwarded excellent specimens of this, well matching the type from Kerikeri, collected near Herekino, also in the North Auckland Bot. Dist.

5. *Isolepis crassiusculus* Hook. f.

Mr. Blake so identifies specimens, in ripe fruit, collected by me in bogs above the forest-line on Mount Hauhungatahi (Volcanic Plateau Bot. Dist.). Possibly some of the records of *I. lenticularis* R. Br. really referred to this species. Mr. A. L. Poole has recently collected the same species on the Kaimanawas.

6. *Poa lindsayi* Hook. f.

Near Lake Taupo (Volcanic Plateau Bot. Dist.), K. W. Allison! Previously reported for North Island only from the Ruataniwha Plains (Ruahine-Cook Bot. Dist.).

7. *Triodia pumila* (T. Kirk) Hack. ex Cheesem.

Near Lake Taupo, K. W. Allison! Cheeseman (1925, p. 182) gives only South Island stations.

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## APPENDIX.

By S. POLGÁR.

1. *Solanum allanii* n.sp.

(There occur numerous forms of *Solanum* in New Zealand at present loosely lumped under *S. nigrum*, and there has long been doubt how far they are indigenous and how far introduced. In an attempt to straighten out the situation I have sent a series of specimens and seeds to Dr. Polgár, of Győr, for his critical examination. From his study of the herbarium material and of plants raised from the seed he has found that while *S. nigrum*, in several varieties, certainly occurs in New Zealand, there are several allied but distinct species as well. Prior to a complete revision of the group Dr. Polgár has kindly supplied the following diagnosis of two of the new species. H. H. A.)

"Suffrutex, sed iam primo anno florens, metralis vel altior (primo anno), ab imo valde ramosus. Caulis basi (primo anno) c. 1 cm. diam., infra lenticellis instructus, interdum subdichotome ramosus rami erecti-patuli vel patentissimi, nonnumquam fere geniculatim flexuosi, subangulati, lineis decurrentibus valde sparse



"Sporting" *Coprosma*: Mayor Island. Two branches from same plant.

—Photo. H. Drake.



gibberes piliferos gerentibus instructi, ceterum glabri (solum partes novellae nondum satis evolutae, sicut pedunculi et pedicelli pilis parvis 1-2-cellularibus sursum curvatis  $\pm$  dense obtectae). Internodia adulta ramorum 6-12 cm. longa; nodi subincrassati.

Laminae membranaceae, tenues, utrinque saturate virides, interdum maculis caeruleis suffusae, margine scabriusculae, utrinque glabrae, solum vena media et primariae laterales pilis minutis curvatis, 1-3 cellularibus vestitae; venae laterales primariae in utroque latere 4-6 curvatim ascendentes, haud prominulae. Laminae deltoidei-ovati-lanceolatae vel rarius ovatae, 5-8  $\times$  2.5-4.5 cm., supra basim latissimae, e basi rotundata vel subtruncata plerumque sensim et aequaliter angustatae, marginibus vix curvatis, acuminatae apice ipso obtusiusculo, satis abrupte  $\pm$  cuneatim in petiolum superne brevi spatio alatum 2-3.5 cm. longum abeuntes, margine solum in parte inferiore usque ad medium (rarius etiam paulum superius) sinuati-dentato vel fere integro, ad apicem versus semper integro, dentibus in utroque latere 1-4 inaequalibus obtusis, 3-5 mm. longis, 5-6 mm. latis. (Solum folia plantae juvenilis fere usque ad apicem sinuati-dentata, dentibus majoribus ad apicem versus diminutis; eorum petioli 3-5 cm. longi.)

Inflorescentia extra axillaris, in statu fructifero in superiore parte usque ad medium internodii sita (3)-4-5-(6)-flora. Pedunculus erecti-patulus, 10-15-(20) mm. longus, fructifer plerumque horizontaliter patens, vix auctus. Inflorescentia umbellam imitans, rhachis etiam in statu fructifero fere nullus, raro flos infimus paulum (1 mm.) remotus. Pedicelli ad apicem versus nonnihil incrassati, filiformes, ante anthesin nutantes, florentes arrecti deflorati decurvi, c. 5 mm. longi; fructiferi 6-8 mm. longi, curvatim subnutantes sed nunquam reflexi.

Flores exigui, 3.5-5 mm. longi, diam. 4.5-6 mm. Calyx campanulatus, 1-1.5 mm. longus, ad  $\frac{1}{2}$  usque ad medium in lobos c. 1-2 mm. longos semiovati-ellipticos obtusiusculos, membrane pellucida conjunctos partitus, in margine pilis minutis 1-2 cellularibus acutis, superficiei praeterea clavaeformibus apice 4-cellularibus vestitus; fructifer parum auctus, arcuate recurvatus, apicibus incrassatis pedicellum amplectans. Corolla pallide vel saturate lilacina, rarius alba, clausa 3.5-4.5 mm. longa, tubo c. 1 mm., limbo plerumque c. 3.5 mm. longo; lobi ovati-lanceolati 2-3 mm. longi, c. 1.5 mm. lati, extus et in margine pilis 1-3 cellularibus acutis curvatis obsiti, apice paulum recurvati. Stamina c. 1 mm. supra basim corollae inserta. Filamenta 0.7-1.2 mm. longa, antheris (saltem tempore florescentiae plenae) fere aequilonga, basi dilatata intus pilis plerumque brevibus, 1-2 cellularibus apice rotundatis (rarius nonnullis tricellularibus) parce (inferne densius) obsita, vel nonnumquam fere glabra. (Pili majores c. 200  $\mu$  complures minores c. 80  $\mu$  longi.) Antherae breviusculae, ellipsoideae, apice erosae, tota longitudine fere aequilatae, 1.2-1.4  $\times$  0.6-0.8 mm., basi bilobae, lobis obtusissimis, parallelis paulum incurvatis, poris introrsis apicalibus obliquis dehiscentes. Granula pollinica diam. 16-18  $\mu$ .

Ovarium ovoideum, c. 1 mm. longum. Stylus staminibus aequilongus vel rarius (praecipue initio florescentiae) illa paulum superans, apice plerumque geniculatim incurvatus, c. 2 mm. longus superne sensim attenuatus, supra basim glabram  $\frac{2}{3}$  -  $\frac{3}{4}$  longitudinis pilis brevibus acutis 1-2 (paucis 3)-cellularibus (longiores 150  $\mu$ ) obtectus. Stigma depressi-globosum, styli apice crassius, c. 200  $\mu$  longum, 300-400  $\mu$  latum. Baccae globosae, parvae, diam. 4-5 mm.; iam immaturae valde nitidae, tunc propter cellulas sub epidermide sitas et granulas caleii oxalici crystallisati continentes ("Kristallsand") punctis exiguis albis adpersae (in plantis exsiccatis haec puncta sunt vix conspicienda), post maturitatem nigrae, nitidae succo obscure violaceo. Semina parva, 1.2-1.5  $\times$  0.8-1 mm., ovati-pyriformia, basi subapiculata, minute papillosa, numerosa (40-75). Granula sclerotica subapicalia semper 2, diam. 0.5-0.7 mm. et insuper saepe 1-4 plerumque minora in partibus diversis baccae pericarpio intus adhaerentia.

Semina no. 2, 3, 6, 8, 9 collecta a Miss L. B. Moore, "on the lava fields, Mount Wellington, Auckland," 1.1938 et accepta a cl. H. H. Allan, deinde e his plantae a me educatae in duobus hortis oppidi Győr (Hungaria occident.) in exemplaribus compluribus.

Flores similes parvos possident:

1. *Solanum adventitium* Polgár, sed folia ovata, corollae alba, calyx baccae accumbens, stylus rectus, granula sclerotica constanter 6, majora etc.

2. *Solanum nodiflorum* Jacq., sed folia integra, corolla alba, baccae majores, granula deficientia, etc.

3. *Solanum minutibaccatum* Bitter (Sol. nova 1, no. 190) habet filamenta et stylos longius pilosos et caret granulis.

4. *Solanum prionoapterum* Bitter (l.c., II, no. 41) differt denticulis ramorum, longitudine et indumento filamentorum et styli, calyce accumbente, etc.

5. *Solanum tenellum* Bitter (l.c., III, no. 79) differt forma foliorum, indumento filamentorum et styli, seminibus perpauca.

6. *Solanum calvum* Bitter (l.c., X, no. 201) differt forma foliorum glabritie completa filamentorum. *S. apopsilomenum* Bitter (l.c., X, no. 208) e Nova Zelandia habet flores multo majores, filamenta omnino glabra, etc.

## 2. *Solanum pachystylum* n. sp.

Verisimiliter suffrutex, sed iam primo anno florens, valde ramosus. Rami c. 3 mm. diam., angulati; lineae decurrentes manifeste prominentes gibberibus piliferis parce obsitae, ceterum rami (praeter partes novellas pilis minutis sparse vestitas) glabri. Internodia adulta 6-7 cm. longa.

Folia parva; laminae—ut videtur—undatae, crassiusculae, fragiles, supra dilute virides, subtus paulum glaucescentes, margine et supra pilis minutis hyalinis curvatis, e basi crassa acutatis sparse obsitae (qua re laminae supra et margine scabridae), subtus glabrescentes, e basi rotundata vel subtruncata oblongi-lanceolatae supra

basim latissimae,  $4.7-2 \times 2.5-1$  cm., tantum in superiore c.  $\frac{1}{2}$  parte angustatae apice acutiusculo, super basim in utroque latere dentibus subacutis 1-2 praeditae, ceterum margine undulata. Vena media utrinque, venae laterales primariae in utroque latere 5-6, subtus parum prominulae. Petiolus superne brevi spatio anguste alatus, 0.5-1 cm. longus.

Inflorescentia extra axillaris, a foliis remota, sed in superiore parte internodii sita, 4-5-flora, subumbellata, florens rhachiole minimo, sed in statu fructifero rhachis c. 2 mm. Pedunculus 1.1-2 cm. longus, fructifer parum auctus, parce pilosus; pedicelli 6-7 mm. longi, glabriusculi, interdum subtortuosi, apicem versus vix incrassati; fructiferi crassi, c. 1 cm. longi, curvatim nutantes, sed non deflexi.

Flores parvi, c. 5 mm. longi; calyx cupuliformis, 1.5-1.8 mm. longis, apice c. 2 mm. diam., glaber (solum in margine rapillis unicellularibus) ad  $\frac{1}{2}$  longitudinis in lobos breves triangulari-semiovatos, c. 0.7-0.8 mm. et fere aequilatos, apice incrassatos trinervios apiculatos partitus; fructifer parum auctus, reflexus. Corolla intense violaceo-purpurea, rotata, diam. 5-6 mm., tubo c. 0.8 mm., limbo 4 mm. longo; lobi ovales, acutiusculi, 1.7-2.4 mm. lati, in margine crebre, extus sparse pilis 1-3 cellularibus vestiti. Stamina 0.8 mm. supra basim corollae inserta. Filamenta antheris subaequilonga, 0.8-1 mm., vulgo omnino glabra, rarissime 1-3 pilis multicellularibus praedita, basi dilatata (hic 0.5 mm. lata). Antherae breviusculae, crassae, ellipsoideae,  $1-1.4 \times 0.7-0.8$  mm., versus stylum falcitum conniventes, basi nonnumquam paulum dilatatae, basi bilobulatae, lobulis obtusis, rimis basim versus angustatis neque poris apicalibus dehiscentes. Granula pollinica diam. 18-21  $\mu$ . Stylus antheras saepe iam ante anthesin  $\pm$  superans vel illis fere aequilongus, rectus, brevis, 0.8-2 (rarissimae 2.4) mm., a basi usque ad apicem aequaliter et pro ratione valde crassus, diam. 0.3-0.6 mm., paulo supra basim glabram, c.  $\frac{3}{4}$  longitudinis papillis unicellularibus usque 80  $\mu$  longis (neque pilis) obtectus. Stigma subcurvatum,  $\pm$  distincte trilobum, lobulis nonnumquam in utroque margine tuberculo praeditis.

Ovarium crassiusculum, 1-1.3 mm. longum et fere aequilatum. Ovula 60-70. Baccae . . . Semina parva  $1.3 \times 1$  mm.

Collegit H. H. Allan, North Island, New Zealand, Mount Wellington, near Auckland, "on lava blocks, flowers violet-purple," Jan., 1935. (Herbarium of the Plant Research Station, Wellington, New Zealand, no. 8954.)

Species ob crassitudinem styli, dehiscentiam anthemarum, structuram stigmatis notabilis. Habitus locum natalem aridum videtur indicare. Affines videntur: *S. apopsilomenum* Bitter e Nova Zelandia (Sol. Nova  $\times$ , no. 208), quod tamen floribus multo majoribus, forma et dehiscencia antherarum etc. differt. *S. depilatum* Bitter e Madagascar austr. (*loc. cit.*, no. 207) differt forma foliorum et styli.



**TRANSACTIONS**  
**AND**  
**PROCEEDINGS**  
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**Mineralogical Notes from the University of Otago, N.Z.  
No. 3—Kaersutite and Other Brown Amphiboles in the  
Cainozoic Igneous Rocks of the Dunedin District.**

By W. N. BENSON.

*[Read before the Otago Branch, October 11, 1938; received by Editor,  
June 4, 1939; issued separately, December, 1939]*

KAERSUTITE, the richly titaniferous end-member of the group of basaltic hornblendes or syntagmatites (Brögger, 1894), was first described by Lorenzen (1884–1886) from Kaersut, Nugsuaks Peninsula, West Greenland. It has since been found in several other regions, and recently Tomita (1934) expressed the view that the occurrence of basaltic hornblende and kaersutite may be regarded as a characteristic of the petrographic provinces of Cainozoic alkaline effusive rocks throughout the world. In his first announcement of the presence of nepheline-bearing rocks in the Dunedin District, Ulrich (1891) gave a careful description of the occurrence of brown amphibole in tinguaita porphyry (later termed “ulrichite”) at Portobello, and at Pine Hill, in a phonolite near the top of Mount Cargill, and in an unspecified rock, probably the kaiwekite at Long Beach. Marshall (1904, 1906) described other occurrences and in particular made a partial analysis of the kaersutite from the Leith Valley described below, but as the amount of alkalies and titanium contained therein was not determined, he was led to conclude that the mineral was a normal pargasite. Later, however (Marshall, 1914) he described the amphibole in the kaiwekite and certain other rocks as “probably barkevikite.” It is now possible to give further details of the development of brown amphiboles during the course of igneous activity in the Dunedin region, and two chemical analyses of kaersutitic examples. For these the writer must express his great indebtedness to Mr. F. T. Seelye, F.I.C., of the Dominion Laboratory, by whom the analyses were made, through the courtesy of the Directors of the Geological Survey and of the Dominion Laboratory. He is also indebted to Dr. F. J. Turner for the measurements of optic axial angles, and to Dr. G. D. Osborne, of Sydney University, for the determination of the refractive indices of the Leith Valley kaersutite. Many of the slides examined in this work (those in which an initial letter precedes the slide-number) were made by Dr. Marshall during his studies of the Dunedin District prior to 1914, which form the basis of much of the writer’s later investigations. Thanks are due to Dr. Marshall also for the loan of additional material for this study and for personally communicated information.

It will be helpful, before describing the features of these minerals in the Dunedin District, to summarise the mode of occurrence of kaersutite at the type-locality, and the general properties of the brown monoclinic amphiboles. Kaersutite was reported by its discoverer, Steenstrup (1884), to occur in a thin vein or dyke cutting through a horizontal sill of peridotite, later described as picrite by Phalen (1904) and Rosenbusch (1908). The optical properties of kaersutite were determined and communicated to Rosenbusch by Ussing, who also provided the material for the more detailed chemical and optical studies of Washington and Wright (1908). Further field and petrographical work was done by Ravn (1911) and Heim (1911)\*, by Krueger and Drescher (1928), and by Drescher (1932), whose studies indicate that a very interesting example of crystallisation-differentiation occurs at Kaersut, recalling some features of the Lugar sill in Ayrshire (Tyrrell, 1917). The Kaersut sill is 50 metres thick, and invades nearly horizontal Cretaceous sandstone, which is slightly fritted at the contact. The picrite-peridotite, though not homogeneous, is apparently not affected by gravitational differentiation. It contains sub-horizontal bands enriched in augite, and at least two well-marked augitic streaks inclined at  $15^\circ$  to the horizontal, intersecting the horizontal bands obliquely. These are 40 and 80 centimetres thick. Through the middle of the sill runs a horizontal sheet of ophitic dolerite 1.2 metres thick intersecting these oblique streaks. In addition there are numerous segregations of kaersutite-bearing pegmatite comprising a horizontal sheet 35-40 centimetres thick traversing the upper portion of the sill, and giving off below and above steeply inclined irregular veinlets, the latter occasionally rising into the overlying sandstones. There are also irregularly lenticular druse-filling masses of pegmatite, and rarely almost vertical thin veins which are bent against the dolerite sheet, or wedge out in the lower portion of the sill. Krueger's opinion that these veins are younger than the dolerite has been confirmed, but that they actually intersect it seems to be incorrect. Some of the larger veins contain in their middle portion finely granular aplite, either sharply distinct from the kaersutite pegmatite or passing gradually into it. Deuteric alterations have affected all these rocks in varying degree. Table I, compiled from Drescher's detailed descriptions, gives the approximate composition of the several types of rocks. Drescher calls attention to the concentration of kaersutite in the pegmatite, the material of which was derived by lateral secretion from the picrite with rising gas-pressure and decreasing temperature; strong resorption of the crystals occurred when the temperature fell below  $350^\circ$  C., and zeolites commenced to form.

Lorenzen's (1886) statement of the composition of the kaersutite was corrected by Washington's analysis of some of the original material, and very similar figures were obtained by Gossner (1929).

\* Heim's figure illustrating the general occurrence is copied in Suess. *La Face de la Terre*, Vol. III-4, p. 1525.

Kunitz (1930) suggested that the rather different figures obtained by him might have resulted from an admixture of pyroxene in the powdered sample he had received, but the similarity of his results to those obtained by Schafer (in Drescher, 1932) from carefully purified material also provided by Drescher supports the latter's suggestion that there may be a real variation in the composition of the kaersutite even within the type locality. Other analyses of titaniferous amphiboles which may be classed as kaersutite (i.e. containing more than 5-6% of  $\text{TiO}_2$ ) have been made by Kawano, Teshima, Ushijima and Washington, and are given in Table II for comparison with the two analyses by Mr. F. T. Seelye of the Dunedin kaersutites. To provide a contrast, analyses of normal basaltic hornblende and barkevikite have also been added.

TABLE I.—COMPOSITION OF THE KAERSUT SILL COMPLEX.

Proportion of Total Mass.	Pierite-Peridotite		Dolerite	Pegmatite	Aplite
	Normal 65.85%	Augitic 30%	2.4%	1.65%	0.05%
$\text{SiO}_2$ .. ..	41.11%	38.48%	44.10%	48.50%	59.77%
$\text{TiO}_2$ .. ..	0.61	1.20	2.76	3.05	0.81
$\text{Na}_2\text{O}$ .. ..	0.72	0.74	2.69	4.39	5.68
$\text{K}_2\text{O}$ .. ..	0.12	0.13	1.17	2.15	6.33
Olivine and Serpentine ..	48	52	—	—	—
Augite .. ..	10 (a)	20	18 (b)	35 (c)	6
Kaersutite ..	4	5	—	44	—
Labradorite ..	6	3	33	10	81
Anorthoclase ..	—	—	—	—	4
Biotite .. ..	—	1	—	—	—
Iron-Ores ..	1	3	4 (d)	2	—
Apatite .. ..	2	1	1	1	—
Secondary ..	28 (e)	17 (f)	44 (g)	8 (h)	9 (h)

(a) Pale violet.

(b) Titaniferous.

(c) Titanaugite with some greenish diopside bordered by darker aegirine and kaersutite in varying proportions.

(d) Ilmenite.

(e) Chiefly chlorite with carbonates of Ca and Mg, biotite, analcite, chalcedony, aluminous minerals and limonite.

(f) Chiefly chlorite; also biotite, analcite, calcite and limonite.

(g) Chiefly nontronite and biotite, with chlorite, calcite and natrolite.

(h) Chiefly natrolite, with pectolite, mesolite and calcite.

The chemical formulae assigned to kaersutite by different authors are in part as follows: Lorenzen (*vide* Doelter, 1914) stated the composition simply as  $5\text{R}(\text{Si}, \text{Ti})\text{O}_3 \cdot \text{Al}_2\text{O}_3$ . Washington (1908) applied the formula of Penfield and Stanley (1907), which seems, however, less satisfactory than a type of ring-formula, which, while maintaining a general metasilicate composition, allows for the presence of a riebeckitic component of the type  $(\text{R}'\text{R}'')\text{R}''' \text{Si}_4\text{O}_{12}$ . Kunitz (1930) proposed the formula  $(\text{SiO}_3)_6(\text{AlO}_2)_2 \text{H}_2 \text{Ca}_2\text{-Mg}_2 \text{Mg}_2$  with replacements of  $(\text{CaAl})$  by  $(\text{NaSi})$ . This does not, however, agree with the results of X-ray structural analysis according to Berman and Larsen (1931), who proposed instead a modification of Warren's (1930) formula, of which a further modification was introduced by Machatschki (1932). Based on all three of these is the formula found by Kawano (1934) to correspond reasonably well with the structure of basaltic hornblendes:—

TABLE II.—CHEMICAL COMPOSITIONS OF BROWN MONOCLINIC AMPHIBOLES.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SiO <sub>2</sub>	41.38	39.52	39.50	39.52	39.70	40.85	39.78	38.30	39.20	38.79	39.01	36.12	42.48	41.12	40.17
TiO <sub>2</sub>	6.75	10.31	10.33	6.74	6.53	8.47	7.00	6.06	6.53	6.66	6.05	4.82	2.90	0.45	3.78
Al <sub>2</sub> O <sub>3</sub>	14.41	11.22	11.12	11.89	11.83	9.89	14.13	12.87	13.87	13.98	13.60	12.46	8.58	11.02	15.09
Fe <sub>2</sub> O <sub>3</sub>	abs.	1.22	0.06	1.50	4.92	8.85	4.61	7.98	4.08	3.15	5.25	9.60	6.81	6.54	5.49
FeO	11.28	8.81	9.44	8.08	5.98	3.96	7.31	6.96	7.33	8.44	7.42	10.43	15.02	17.73	5.99
MgO	13.51	13.31	12.90	14.19	14.72	12.47	11.01	11.70	11.96	11.88	11.73	9.09	2.78	6.14	12.48
CaO	12.97	10.93	10.91	13.72	12.52	12.16	10.75	10.47	12.37	12.20	12.05	12.01	13.45	10.42	11.21
Na <sub>2</sub> O	n.d.	2.95	3.82	3.34	1.84	2.01	2.57	3.11	1.99	2.42	2.51	2.58	6.32	3.65	2.27
K <sub>2</sub> O	n.d.	1.07	1.43	1.09	1.29	0.63	1.58	1.30	1.45	0.92	1.11	1.41	0.60	0.94	1.55
H <sub>2</sub> O—	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.22	0.62	0.27	0.40	0.19	n.d.	n.d.	n.d.	0.25
H <sub>2</sub> O+	n.d.	0.59	0.59	0.40	0.85	0.19	0.37	1.10	0.87	0.93	0.98	1.02	0.25	1.45	2.10
CO <sub>2</sub>	—	—	—	—	—	—	—	—	—	abs.	abs.	—	—	—	—
P <sub>2</sub> O <sub>5</sub>	—	—	—	—	—	—	abs.	—	abs.	0.03	0.03	—	—	—	—
F	—	—	—	—	—	0.28	—	0.05	—	abs.	abs.	—	—	—	—
MnO	—	0.06	0.10	0.19	—	0.12	0.12	0.12	0.11	0.18	0.14	0.28	0.39	1.03	0.09
NiO	—	—	—	—	—	0.10	—	—	—	0.03	0.03	—	—	—	—
BaO	—	—	—	—	—	—	—	—	—	0.03	0.03	—	—	—	—
Etc.	0.26	—	—	—	—	—	—	—	—	0.02	tr.	—	—	—	—
Total	100.56	99.99	100.20	99.72	100.18	99.98	99.45	100.73	100.03	100.06	100.13	99.82	100.18	100.49	100.47
Sp.G.	3.04	3.137	—	—	—	3.336	3.261	3.322	3.264	—	3.272	3.330	3.298	3.415	3.178

1. Kaersutite, Greenland, J. Lorenzen (1884) Anal. (TiO<sub>2</sub> low, Fe<sub>2</sub>O<sub>3</sub>) and alkalies are not reported. The stated presence of 0.26% of SnO<sub>2</sub> was not confirmed by Washington (1908).
2. Kaersutite, Greenland, Washington (1908) Anal. (Corrected by excluding a small amount of Ca<sub>3</sub>P<sub>2</sub>O<sub>7</sub>).
3. Kaersutite, Greenland, Gosner (1929) Anal.
4. Kaersutite, Greenland, Schaffer in Drescher (1932) Anal.
5. Kaersutite, Greenland, Kunitz (1930) Anal.
6. Kaersutite, Greenland, Kunitz (1930) Anal.
- NOTE.—Specimens 1-5 from kaersutite pegmatite.
7. Kaersutite (Jinosite) Linosa. In basalt tuff. Washington (1908) Anal.
8. Kaersutite, Doko, Oki Island. In basalt dyke. Teshima (in Tomita, 1934) Anal.
9. Kaersutite, Uryon, Korea. In andesine basalt, Ushilima (in Kawano, 1934) Anal.
10. Kaersutite, Furkanui, Dunedin, N.Z. In kalvekkite. F. T. Seelye Anal. (including S = 0.02%).
11. Kaersutite, Leath Valley Quarry, Dunedin, N.Z. In trachybasalt. F. T. Seelye Anal. (including a trace of S).
12. Dark brown barkevikite, Fuerteventura, Canary Islands. In essexite. Kunitz (1930) Anal.
13. Red-brown barkevikite, Lugar, near Mauchline, Ayrshire. In ligarite. Scott (1914) Anal.
14. Green-brown barkevikite, Stavarsjø, Norway. In nepheline syenite. Kunitz (1930) Anal.
15. Basaltic hornblende, Lake Balaton, Hungary. In basaltic tuff. Vond. (1924) Anal.
- \* There are minor discrepancies between Kawano's and Tomita's data of analyses Nos. 8 and 9.

$(O, OH, F)_2(Ca, Na, K)_{2-3}(MgFe''Mn, Fe''', Ti)_5((SiAl)_4O_{11})_{12}$   
Utilising this formula, the above analyses may be stated thus:—

Analysis	(O, OH, F)	(Ca Na, K)	(Mg, Fe'', Mn, Fe''', Ti)	(SiAl) <sub>4</sub> O <sub>11</sub>	Note
No. 2	2	2.4	5	4 11 12	
4	2	3.3	5	4 11 12	
5	2	2.5	5	4 11 12	(a)
7	2	2.7	4.4	4 11 12	(b)
8	2	2.8	5	4 11 12	
10	2	2.3	4.7	4 11 12	
11	2	2.8	4.8	4 11 12	(c)
12	2	3.0	5	4 11 12	
15	2	2.5	5	4 11 12	(d)

(a) If a quarter of the  $TiO_2$  acts as  $SiO_2$ .

(b) If a third of the  $Al_2O_3$  is included with  $R''$ .

(c) If a thirtieth of the  $Al_2O_3$  is included with  $R'''$ .

(d) If but little of the  $H_2O+$  is included in the molecule.

The usually small amount of  $Fe_2O_3$  in kaersutite has caused Winchell (1933) to exclude it from the oxyhornblendes with which he groups most of the basaltic hornblendes. The kaersutite of Linosa is abnormal in this respect and may have been exposed to strongly oxidising high-temperature conditions, accounting for its high refractive indices and birefringence (cf. Kozu, Yoshiki and Kani, 1927, Barnes, 1930, Larsen, Irving and Gonyer, 1937). Murgoci's earlier suggestion (1922) was to define basaltic hornblende chemically as containing much  $(Fe, Al)_2O_3$ , with  $MgO/FeO = 6$  and  $MgO/CaO = 3/2$ . The linosite differed in that  $MgO/FeO = 5$ , and kaersutite in containing more  $TiO_2$  and  $FeO$  with less  $(Al, Fe)_2O_3$  than basaltic hornblende.

No means are here available to determine the lattice-dimension of the Dunedin kaersutite. The following figures are cited as being probably comparable therewith. The Anakie hornblende is strongly oxidised ( $Fe_2O_3 = 12.02\%$ ) and rich in  $TiO_2$  (5.40%).

TABLE IV.—LATTICE-DIMENSIONS OF BASALTIC HORNBLENDES.

Mineral	a	b	c	Authority
Kaersutite, Greenland	9.85 Å	18.17 Å	5.37 Å	Gossner and Spielberger (1929)
Kaersutite, Korea	9.77	17.85	5.32	Kozu and Tanaka <i>vide</i> Kawano (1934)
Basaltic Hornblende, Anakie, Victoria	9.88	17.85	5.44	Parsons (1930), Greenwood and Parsons (1931)

Measurements have been made of the optical properties of amphiboles in well-known rocks that have been classed as barkevikite or barkevikitic hornblendes by authoritative petrologists. Thus, in a lugarite obtained by the writer from the type locality, though the extinction-angle of the amphibole was that cited above ( $11^\circ$ ), the optic axial angle determined by Dr. Turner was  $68^\circ$ – $72^\circ$ . In the teschenite of Neutitschein, Moravia, in which the amphibole was described by Rohrbach (1885), cited by Rosenbusch (1907) and Johannsen (1934), as barkevikitic hornblende, the extinction-angle is nearly  $20^\circ$ , but  $2V$  is  $74^\circ$ – $84^\circ$ , as measured by Dr. Turner. The

barkevikitic hornblende in sample of laurvikite from Quen and Tjolling, near Frederiksværn, South Norway, originally described by Brögger, showed  $c \wedge Z = 12^\circ$  with  $2V = 60^\circ-66^\circ$ , in the former case, and  $76^\circ-78^\circ$  in the latter (*vide* Turner).

The optical properties of the various amphiboles of which the analyses are cited here are recorded in the following table:—

TABLE V.—OPTICAL PROPERTIES OF ANALYSED BROWN AMPHIBOLES.

Anal. No.	$110 \wedge 110$	$c \wedge Z$ on 010	$c \wedge Z'$ on 110	$\alpha$	$\beta$	$\gamma$	$\gamma - \alpha$	2V— Cnl.	2V— Obs.	Authority
1	$55^\circ 35'$	$10^\circ a$	$8-9^\circ b$	1.676	1.694	1.708	.32	$82^\circ$	$81^\circ$	Ussing
2	$55^\circ 35'$	$12^\circ$		1.692	1.730	1.760	.068	$82^\circ$	$82^\circ$	Wright
4-5		$1.4^\circ$		1.687 $c$	1.705	1.718	.031	$80^\circ$	$72^\circ$	Drescher
6	$55^\circ 43'$	$4.4^\circ$		1.684	1.701	1.720	.036	$79^\circ$	$80^\circ$	Wright
7				1.680	1.701	1.709	.029			Tomita
8				1.6821	1.6975	1.717	.035		$75^\circ$	Tomita
9	$55^\circ 25' d$	$2^\circ$	$1^\circ$	1.687	—	1.708	.021		$78^\circ f$	(e)
11		$10^\circ$		1.680	—	1.701	.021		$52^\circ$	(g)
12	$55^\circ 30'$	$11^\circ$		1.687	—	1.701	.014		$54^\circ$	Scott
13		$18^\circ$		1.670	1.682	1.693	.023	$84^\circ$	$83^\circ$	(g)
14		$8.7^\circ$								Vendl
15										
X				Y			Z			
1	light brown			dark reddish-brown			darker reddish-brown			Ussing
4-5	light straw-brown			brown-red with chocolate tinge			brown-red			Drescher
6	pale olive-brown			brown			very dark-brown			Wright
7	pale yellow-brown			reddish-brown			greenish-brown			Tomita
11	pale straw-brown			reddish-brown			darker reddish-brown			
12	light yellow-brown			reddish-brown			dark brown			
13	light yellow			reddish-brown			very dark brown			
15	pale yellow-brown			dark green			dark brownish-olive			

(a) Not stated whether  $c \wedge Z$  or  $c \wedge Z'$  measured on 110.

(b)  $c \wedge Z$  greater for red than for green light.

(c) Measured in Na light. The complete range of refractive dispersion is determinable from Tomita's data.

(d) Mean of eight measurements with range  $4'$ .

(e) Measurements of  $\alpha$  and  $\beta$  and also of  $n_p = 1.6932$  in a cleavage-flake (all  $\pm .0002$ ) were made in Na light on an Abbe refractometer by Dr. G. D. Osborne. Measurements of  $\gamma = 1.717 \pm .003$  and of  $n_g = 1.716 \pm .003$  were made in similar light on a Rayner refractometer by Dr. G. D. Osborne, of Sydney University.

(f) Mean of  $76^\circ$ ,  $78^\circ$  and  $80^\circ$  measured by Dr. F. J. Turner on different parts of one crystal slice cut perpendicularly to the vertical axis.

(g) Measurements of refractive indices and extinction-angles made by Kunitz on analysed crystals. The optical axial angle is that given by Johannsen (1908) and Larsen and Berman (1934) as characteristic of barkevikite. Winchell (1933) gives  $2V = 81^\circ-52^\circ$ .

From the above data it would appear that the distinction between barkevikite, barkevikitic hornblende and basaltic hornblende, which may be drawn chemically on the proportion of MgO to FeO (increasing in the above sequence), cannot be based satisfactorily on either the intensity of the reddish tinge for Y and Z or on the refractive indices. The range of the latter for barkevikites is  $\alpha = 1.680-1.694$  and  $\gamma = 1.701-1.708$  with  $c \wedge Z = 10^\circ-20^\circ$ , and for basaltic hornblendes  $\alpha = 1.667-1.681$  (extended to 1.687 by Tomita) and  $\gamma = 1.688-1.701$  (extended to 1.720 by Tomita) with  $c \wedge Z = 0-12^\circ$ . The use of the extinction-angles and optic axial angles may, however, lead to a conventional separation, and it is proposed in the sequel to term "barkevikite" amphiboles with 2V less than  $60^\circ$ , and "barkevikitic hornblende" those with 2V greater than  $60^\circ$  and  $c \wedge Z$  more than  $10^\circ$ , while "basaltic hornblende" will denote those amphiboles with 2V greater than  $70^\circ$  and  $c \wedge Z$  less than  $10^\circ$ . There does not seem to be any optical grounds for the distinction of richly sodic barkevikite (Anal. No. 13) from varieties containing but little soda (Nos. 12 and 14). Nor are there obvious optical grounds for the distinction of richly titaniferous basaltic hornblendes (kaersutite) from those with a small content of  $\text{TiO}_2$ . High refractive indices may result either from an increased content of  $\text{Fe}_2\text{O}_3$  as in basaltic oxyhornblende or from increased  $\text{TiO}_2$  as in kaersutite. The highest figures occur in amphiboles in which both these oxides are very abundant, as in *linosite* (Anal. No. 6). The optic axial angle is high, the extinction-angle small and the pleochroic tints fairly uniform throughout the basaltic hornblende group, though greenish tints have been noted in some richly ferric examples (Kunitz, 1930; Parsons, 1930).

#### OCCURRENCE OF BROWN AMPHIBOLES IN THE DUNEDIN DISTRICT.

The igneous activity commenced in the late Cainozoic times after the penetration of warped Middle Cainozoic sediments (see Benson, 1934). The earliest products of eruption were anorthoclase trachytes as tuffs, breccias, flows and dykes, among which amphibole is occasionally present though usually too altered for investigation. What may be a late member of these intrusions occurs as a dyke (No. 2957 in the collection of the Geological Department of Otago University) crossing the roadway half a mile S.S.W. of Harbour Cone. It is a trachyandesite with oligoclase both as phenocrysts and in subordinate laths among the sanidine in the base. Though pale titanite occurs as phenocrysts and in the base, the more abundant dark mineral is a perfectly fresh unresorbed amphibole in prisms up to  $2.2 \times 0.4$  mm. and small ground-mass prisms up to  $0.1 \times 0.03$  mm. The optical characteristics of these are noted in Table V. The larger prisms are frequently twinned and permit the determination of the extinction angle on the universal stage by Nemoto's (1938) method.

Later than the trachytes, and possibly also later than this trachyandesite, are the hornblende basalts which are among the concluding members of the lavas of the first volcanic phase occurring in the Mornington portion of the Dunedin urban area. The amphibole in these is generally resorbed, but occasionally (e.g. in No. 26) is determinable. In this rock the phenocrysts are up to  $3 \times 1$  mm. in size, though usually more slender. Sometimes they are entirely surrounded by

a mantle of titanaugite, the *b* and *c* crystallographic axes of the two minerals being common. In these rocks also are large ( $0.5 \times 0.2$  mm.) prisms of faintly dichroic apatite containing long fibres or sheets of minute greyish or brownish inclusions arranged parallel to the vertical axes or more rarely perpendicularly to the prism faces. Edwards (1938, pp. 303-6) considers that similar inclusions in the unusually large apatites in Victorian basalts may be remnants of hornblende, and remarks that "such apatites are associated with the breaking down of basaltic hornblende in trachytes from New Zealand and many rocks from Kerguelen Island." Certainly the presence of such large apatites in the rocks of the Dunedin district is almost invariably in association with more or less resorbed hornblende, and usually with signs of greater alkalinity than that of normal olivine basalt. The amphiboles commonly display a narrow border-zone of densely aggregated minutely granular iron-ore (probably titaniferous magnetite) almost obscuring a background of titanaugite, the last often extended into a thin clear film enclosing the darkened interior. The pyroxene over considerable areas may be crystallographically in parallel growth with the amphibole (as noted above), but generally this condition does not extend throughout, and much of the pyroxene is quite haphazard in its orientation. Though the finely granular dark aggregate may often extend from the marginal zone throughout the whole of the space occupied originally by the amphibole, as in the "ghost crystals" of Tomita, the inner portion is as a rule less rich in iron-ore, and small secondary plagioclase laths may be seen to have developed among the new-formed pyroxene. Often this more open structure may extend to the margin of the paramorph. Concentration of the minute magnetite grains into vertical and rarely intersecting lines indicating that resorption changes proceeded along the cleavage-planes inwards from the margin (as Rosenbusch, 1908, noted) has frequently been observed in these rocks. It was not possible, however, to confirm Tomita's statement that in such replacements the new-formed pyroxene was never pigeonitic, though the large optic axial angle of normal titanaugites was observed in several instances. No hypersthene or olivine was noted among the resorption-products.

In other cases the material within the darkened margin is less finely granular. The distinctive feature is the occurrence of platy or "club-shaped" masses up to  $0.20 \times 0.02$  mm. in length and breadth, commonly elongated parallel to the vertical axis of the amphibole, but also occurring either perpendicular or at  $60^\circ$  thereto, or forming tufts composed of a few such plates spreading towards the interior of the original crystal, or in shorter smaller and less regularly placed plates. The pleochroism of such new-formed plates is intense. Sections changing from greenish-brown to dark reddish-brown have their maxima markedly oblique to their elongation, which is nearer to the vibration plane giving reddish-brown. Sections changing from reddish-brown to an almost opaque red-brown show maxima more nearly parallel to the elongation, but because of the invariable presence of pyroxene within the thickness of the rock-slice the optical orientation cannot be stated definitely. This, doubtless the "brown material" described by Washington (1894), is probably

rhönite such as was formed in Tomita's (1934) kaersutites. Scattered magnetite and small secondary plagioclase laths are also developed in this connection (see Fig. 1, A). Rosenbusch's (1908) comment that the hornblendes in many basalts have xenocrystic characters or occur only where the basalts are rather abnormal or alkaline is generally applicable to the Dunedin district. The larger brown crystals, though often idiomorphic, are commonly more or less corroded or rounded. They may contain large apatite prisms, which, as noted above, may also occur separately in the ground mass, and

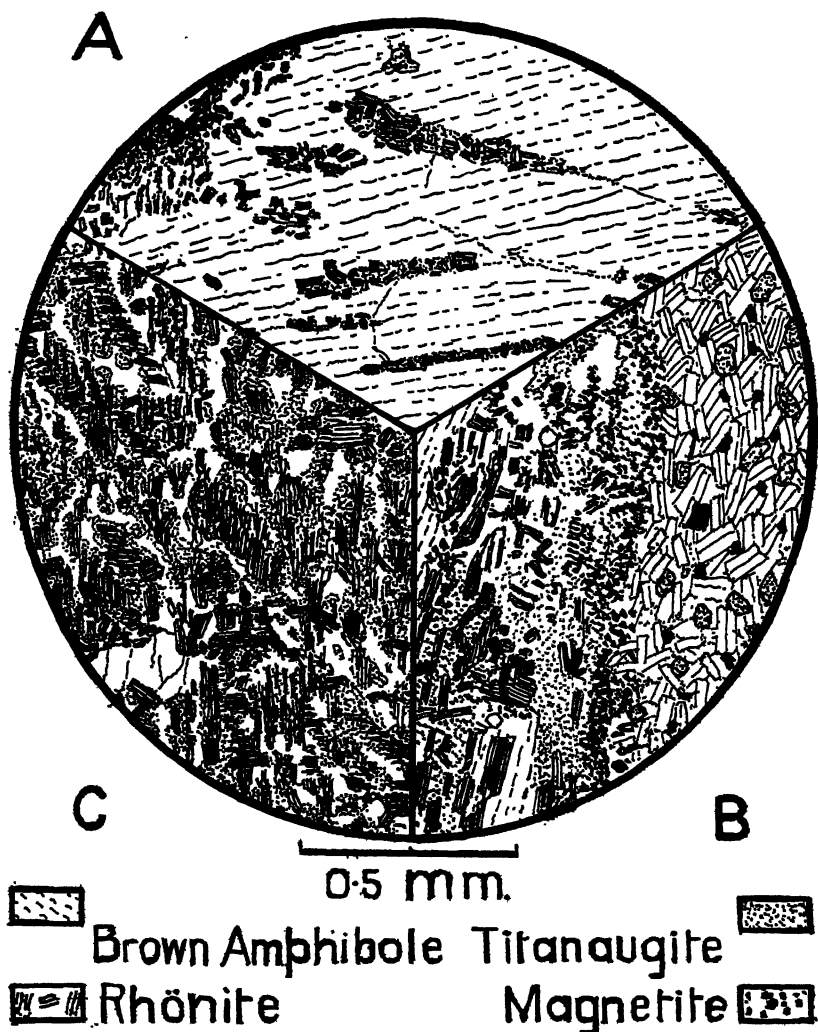


FIG. 1.—Transformation of kaersutite to rhönite and finely divided magnetite.  
 A. Commencement of the change in inclusion of pegmatoid gabbro-essexite in the breccia; Port Chalmers (D1).  
 B. Further stage with marginal concentration of the magnetite, and some separation of titanaugite. In hornblende basalt (26), Mornington, Dunedin.  
 C. Complete replacement of kaersutite, by rhönite, titanaugite, magnetite and plagioclase in gabbroid inclusion in basalt (522). Western side of Flagstaff Hill.

when either brown amphibole or large apatite prisms are present in a basaltic rock, a little sanidine is usually determinable between the laths of andesine or labradorite. Where this is more obvious the rock is classed as trachybasalt, a flow of which (697) occurs among the older first-phase lavas near Port Chalmers, another (387) among the later first-phase lavas near Purakanui, and others elsewhere, in which not only resorbed amphibole but also phenocrystic aegirine-augite is surrounded by a mantle of titanite.

The source of the presumably cognate amphibole xenocrysts may be inferred from the nature of the inclusions in the kaiwekite (Flow No. 13 of Marshall's North Otago Head sequence), a porphyritic olivine-bearing anorthoclase "trachyte," one of the latest of the lavas of the first volcanic phase. Brown amphibole occurs in this in three ways:—

- (1) In inclusions of pegmatoid kaersutite-pyroxene-gabbro (or gabbro-essexite).
- (2) In inclusions of nepheline syenite pegmatite.
- (3) In large single crystals or crystal-clusters.

1. Specimens of these inclusions have been obtained both in the cliffs at the northern end of Long Beach (Purakanui), where they are common, and at North Otago Head. The presence of feldspar is not obvious in hand specimens, though a lustre-mottling of the hornblende cleavage-planes (up to 3 mm. long) shows the presence of inclusions therein. Microscopically (961, 4729, see Fig. 2, A), kaersutite is seen to be the dominant mineral and has the optical properties noted on Table VI. It occurs in large poikilitic masses containing minute dark brown translucent schiller-plates elongated usually parallel, but also perpendicularly to the vertical cleavage. Irregular grains of magnetite 0.1–0.2 mm. in diameter are scattered sparsely through it, rare apatite prisms, more abundant colourless grains of olivine up to 3 mm. across (the optic axial angle of which  $2V = 82^\circ$ — indicates a composition of Fa 32%), and still more abundant masses of pyroxene occurring as subidiomorphic prisms  $5 \times 1$  mm. in size fraying out into mutually poikilitic intergrowth with one or more of the large kaersutite individuals, or as separate but irregularly bounded grains scattered with or without optical parallelism through the amphibole or the plagioclase-background. Sometimes the parallel position of mutually intergrown pyroxene and amphiboles may be observed; at other times the latter mineral seems to be merely a thin film surrounding the former and giving it the appearance of possessing a faintly pleochroic brownish tint. The pyroxene is not homogenous. Though usually a pale greenish diopside, portions of a single optically continuous grain may pass into an irregularly not zonally bounded mass of titanite. Subidiomorphic grains of titanite are also scattered haphazardly or regularly oriented through the amphibole, or may occur embedded in plagioclase with or without an enclosing film of amphibole. The pleochroism of such titanite is very marked and follows the normal scheme. There is little difference of optic axial angle between the several types of pyroxene. The clear greenish diopside has  $2V = 58^\circ$ – $62^\circ$ , the schillerised colourless pyroxene  $53^\circ$ – $62^\circ$ , and the schillerised titaniferous

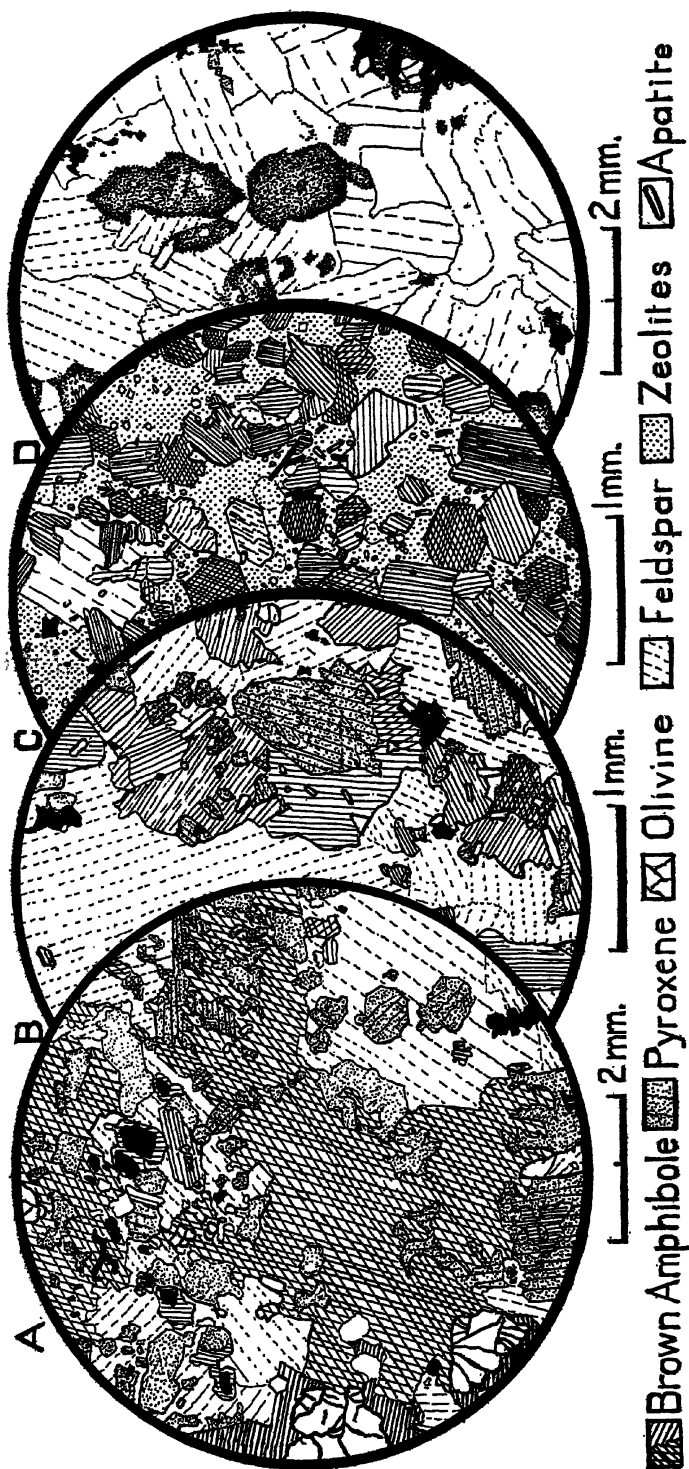


FIGURE 2.

- A. Kaersutite, titanite and diopside, olivine, labradorite, magnetite and apatite in pegmatoid gabbro xenolith (4720) in kaibekite; North End of Long Beach, Purakamul.
- B. Kaersutite, titanite, diopside and andesine with magnetite in pegmatoid gabbro-esserite inclusion (D3) in breccia; Port Chalmers.
- C. Barkevikite hornblende, orthoclase (?) and analcite with magnetite and abundant apatite in a turbid zeolitised base. Inclusion of zeolitised ligurite (C2) in breccia; Port Chalmers.
- D. Pseudomorphs in finely divided magnetite after barkevikite (?) with orthoclase, oligoclase-andesine, and nepheline in nepheline syenite (C7). Probably inclusion in breccia; old shaft, Battery Creek, Harbour Cone.

variety 52°–60°. It is noteworthy that Drescher (1932) calls attention to the varying colour of the pyroxene in the dolerite invading the Kaersut picrite sill, and considers it to result from an uneven concentration of  $\text{TiO}_2$  such as is indicated by his detailed study of the associated iron-ores. But though diopside and titanite occur together in the kaersutite-augite-pegmatite of Kaersut (to which the rock under consideration has considerable resemblance), diversity of colour in a single grain has not been recorded therein by Drescher. The plagioclase grains in our pegmatoid gabbro are also poikilitic, up to 6 mm. in diameter, of labradoritic composition ( $\text{Ab}_{40}$ ) and faintly schillerised. It varies greatly in amount from 20% to 90% in the range of specimens examined.

Connecting these pegmatoid gabbro inclusions with those of nepheline syenite is a xenolith of a rather essexitic composition. It contains about 40% of andesine, which is not poikilitic, and is associated with a small amount of orthoclase and of nepheline with secondary analcite. Pyroxene in large poikilitic masses forms the dominant coloured mineral and is usually titaniferous, but with a faintly pleochroic bright green alkaline margin. Brown amphibole with  $c/\angle Z = 12^\circ$  occurs intergrown with this pyroxene, and is marginally resorbed with the formation of finely granular magnetite. There is much idiomorphic apatite in both coloured and colourless minerals, but no olivine.

2. A rock obtained by Dr. Marshall as an inclusion almost certainly from the kaiwekite of North Otago Head proves to be a fragment of nepheline syenite, in which a small amount of largely resorbed brown amphibole containing apatite and aegirine-augite occurs with more abundant separate crystals of this pyroxene and of anorthoclase, the last forming large poikilitic masses through which are scattered optically parallel grains of nepheline and of aegirine-augite. The coloured constituents together comprise less than a fifth of the rockmass. The cores of residual amphibole give tints of golden to deep red-brown. The optic axial angle was not determinable.

3. The scattered individual crystals of amphibole are up to 4 cms. in diameter. Several of these were crushed and a sample composed of clean cleavage-fragments free of any lustre-mottling selected under the microscope was analysed by Mr. F. T. Seelye (see Table II, No. 10). On such fragments  $c/\angle Z'$  is nearly  $10^\circ$  in flakes parallel to (110), and the Y and Z brownish colouration has but little of the reddish tint of barkevikite. In smaller crystals scattered throughout a representative series of kaiwekites a range of optical properties was observed which are indicated in Table VI.

The characters of the coarsely crystalline inclusions of the group first described recall not only those of the kaersutite pegmatites of Greenland, but also those of certain pegmatoids described by Lacroix (1928) in volcanic rocks of basaltic facies. The mutual poikilitic intergrowth of the coloured constituents and their enclosure by plagioclase is in particular comparable with the features of pegmatoids, though there is not among the present group of inclusions any development of interstitial finely lathy alkaline feldspar (the association of which with more coarsely granular material is especially

characteristic of pegmatoids), and but little primary zeolite, which, however, is seen among other coarse-grained inclusions occurring in rocks belonging to a later phase of the Dunedin volcanic series. It is probable, however, that in spite of their close similarity with the rocks of the Kaersut complex, the inclusions here described were developed as local segregations from magmas rather than as portions of individual rock-masses which have been included as fragments in the rocks in which they are now embedded. If that be the case, the diversity between the types of coarsely granular inclusions (1 and 2) in kaiwekite is in accord with the view to be discussed elsewhere, that kaiwekite is a hybrid rock produced by the mingling in varied proportions of diverse partially crystallised magmas.

The first volcanic phase in the Dunedin area closed with a varied series of intrusions, and explosive eruptions producing immense vent-filling breccias. Brown amphibolites of several types occur among the products of these. A "camptonitic" dyke (J.10, La. 16, La. 17\*) described by Marshall (1906, p. 398) from near Portobello is noteworthy for the presence of much thompsonite and analcite, as indicated by chemical and optical tests including staining (Marshall, *priv. com.*). Phenocrysts of pale green or colourless diopside occur.

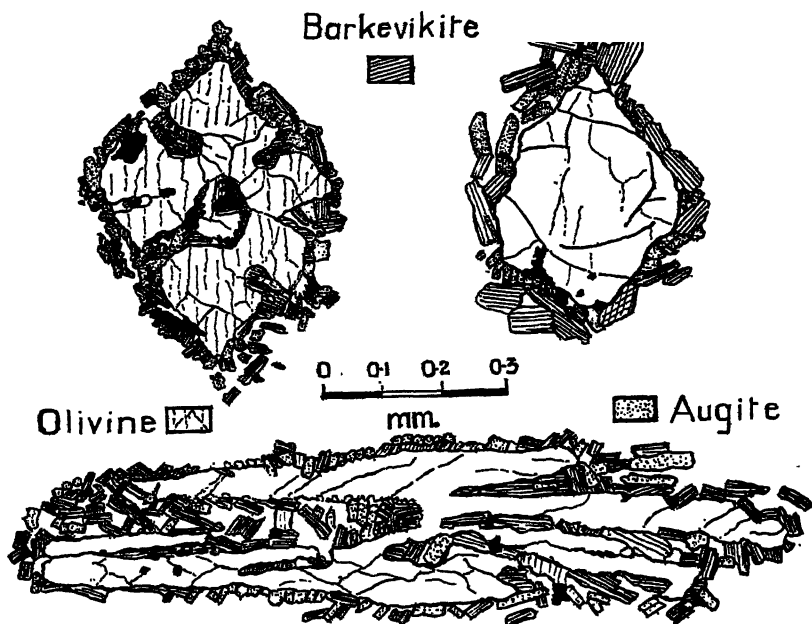


FIG. 3.—Barkevikitic hornblende associated with a little biotite mantling idiomorphic or corroded olivine in a camptonitic dyke (J10); Portobello.

The amphibole phenocrysts are free from any resorption and may contain a core of pyroxene. They are often twinned and faintly zoned, and form prisms up to  $2.0 \times 0.8$  mm. in size. Small (0.3 mm.)

\* Microscope slides, of which the catalogue numbers are prefixed by a letter or letters, were used by Marshall, and in general no corresponding rock-specimens are now available.

phenocrysts of ilmenite are also present, and contain minute prisms of barkevikite and apatite. The groundmass includes many small thin amphibole prisms and shorter prisms of pyroxene. The optical properties of the amphibole are noted in Table VI, the smaller optic axial angle and more reddish colour of the central portions may betoken a more alkaline or barkevikitic composition than that possessed by the outer portion, though the birefringence and extinction-angle (indicated by Nemoto's method of determination) remain constant throughout. There is commonly a very thin greenish marginal film which is possibly arfvedsonitic ( $2V = 68^\circ$ ) fraying out into the zeolitic groundmass. The groundmass-amphibole occasionally appears wrapped about small sometimes corroded olivine phenocrysts, where it may be associated with flakes of biotite (see Fig. 3).

The "tinguaitic camptonite" or ulrichite of the Portobello Peninsula (Marshall, 1906, p. 397) is closely similar to the above. It (J.24) contains amphibole recognised as barkevikite by Marshall (see Table VI) associated with and sometimes containing idiomorphic

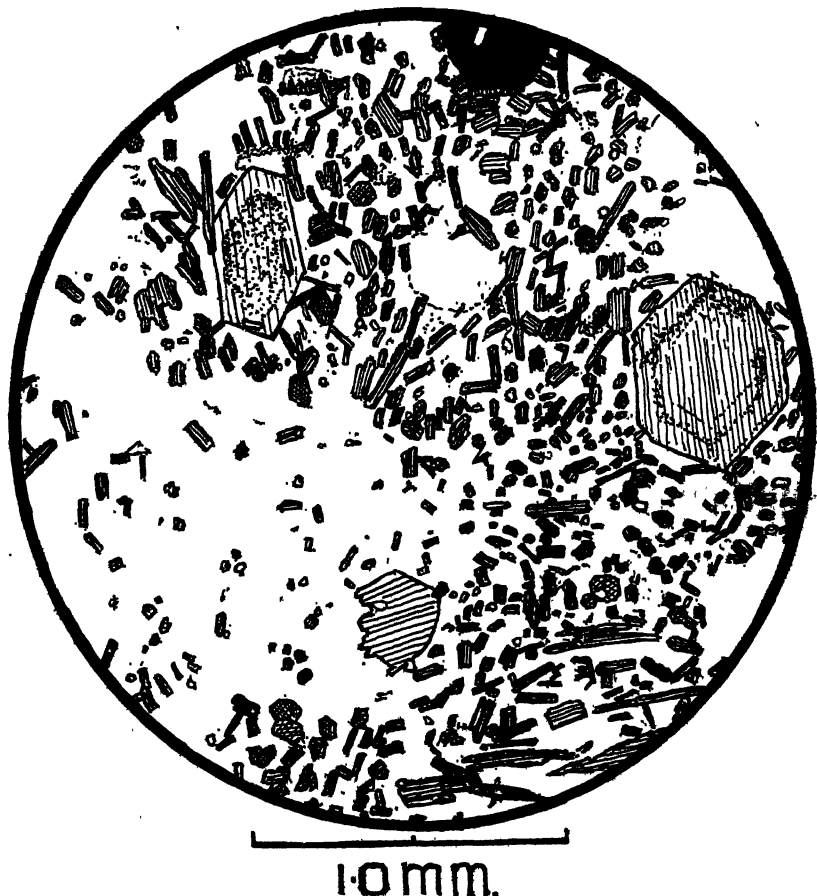


FIG. 4.—Irregularly shaped masses rich in barkevikite in a camptonitic groundmass containing relatively little amphibole (La2). Dyke, Portobello.

olivine ( $2V = 86^\circ$  (—): Fa 24%), without regular orientation. Another allied dyke rock from Portobello (La.2) is noteworthy for the presence of irregular masses of a richly hornblendic camptonite in a leucocratic host (see Fig. 4).

A nepheline syenite porphyry forms a laccolitic intrusion occupying most of Varley's Hill on the northern side of Hooper's Inlet. It was first described as a tinguaita (Marshall, 1906, p. 396) and attention was drawn to the formation of groups of aegirine, magnetite and analcite derived from resorbed brown amphibole, of which some portions remain. The rock (J.3, J.15) consists chiefly of phenocrysts of anorthoclase, nepheline and more or less resorbed amphibole in a matrix of lathy sanidine, short prisms of nepheline aegirine-augite,

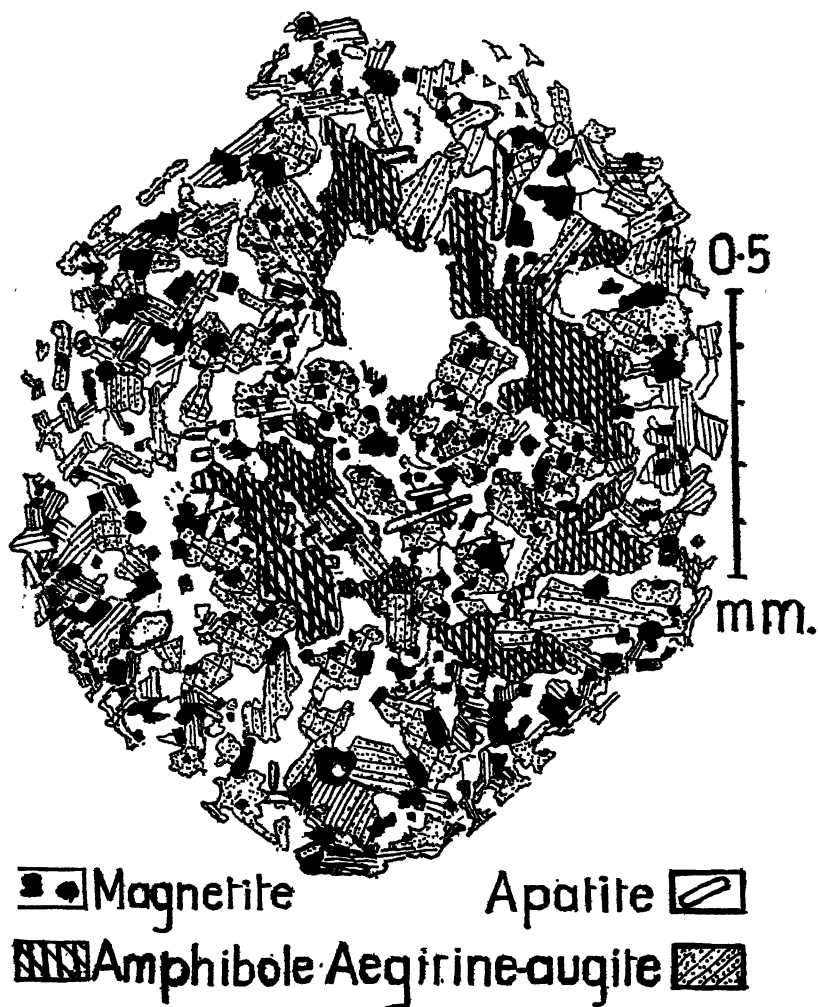


FIG. 5.—Basal section of a largely resorbed crystal of barkevikitic hornblende, replaced by green aegirine-augite partly in parallel intergrowth (stippled) magnetite, plagioclase and analcite. Abundant small prisms of apatite shown by dark margins. In nepheline syenite porphyry (103); Varley's Hill, Hooper's Inlet.

a little magnetite and interstitial analcite, the last mineral also occurring in goedes with natrolite and aegirine prisms. The remnants of amphibole, possibly as a result of the deuteric reactions, show a considerable range of optical characters. The value of  $2V$  varies between  $46^\circ$ —(barkevikite) and  $80^\circ$  (—) (basaltic hornblende) though in ten other cases it lies within  $8^\circ$  of  $60^\circ$  (—). Where faintly-marked zoning is present, the darker outer zone has a lower value for  $2V$  ( $62^\circ$ — and  $58^\circ$ —), the same value for  $\gamma$ — $\beta$  and the same or rather higher value for  $\beta$ — $\alpha$ . The extinction-angle  $c \wedge Z$  is  $9^\circ$ — $12^\circ$ , and the pleochroism shows X pale straw-yellow, Y deep red-brown or deep golden-brown, and Z deep brown or deep golden-brown with absorption  $X < Y < Z$ . Occasionally the amphibole contains diopside with  $2V = 64^\circ$ . The resorbed portions of the amphibole, though generally free of very finely divided magnetite, commonly contains rather coarsely granular magnetite, especially in the outer portions, probably as a result of the long duration of the conditions favourable to resorption. Aegirine-augite, either originally enclosed in the amphibole, or resulting from its resorption, is usually oriented so as to have the crystallographic axes b and c in common therewith, where the two minerals are in contact, but it often forms a series of short variously oriented prisms outlining or scattered through the space occupied originally by the amphibole. The inner portion is commonly a spongy aggregate of pale green aegirine-augite, nepheline, sanidine (?), analcite and sometimes natrolite with prisms of the originally enclosed apatite. There is a suggestion in the distribution of the pyroxene that it was to some extent strewed about during the resorptive reactions. Figure 5 herewith supplements Marshall's illustration (1906, Pl. XXXVII, Fig. 1) of these interesting pseudomorphs.

The explosive eruptions which preceded the effusions of the second volcanic phase produced a row of breccia-filled vents ranged along an anticline extending S.S.E. through Port Chalmers, where is the largest vent. Amphibole is present in the breccia either as separate crystals, or as a component mineral of various fragments of rocks included therein. Of these the most noteworthy are (1) the nepheline syenites or foyaites at Port Chalmers and the foot of Harbour Cone. In the latter locality Boulton (1906) and Marshall (1906) thought these rocks to be portions of an intrusive mass ascending nearly to the present surface. The writer considers their immediate derivation from a breccia to be more probable. There are also (2) nepheline syenite porphyries as inclusions at Port Chalmers not unlike those *in situ* at Varley's Hill (3) a dark coloured rock formerly classed as diorite but closely similar to the above described pegmatoid gabbro in the kaiwekite, and (4) a probably analogous rock in the breccia at Harbour Cone described by Boulton (1906), who suggested that the greenish-brown amphibole therein was allied to hastingsite, but gave no evidence to support this. None of this last rock has been available for the present study. Some details concerning these inclusions are as follows:—

2. In the Harbour Cone syenite the amphibole formed prisms in size about  $2.0 \times 1.0 \times 0.8$  mm. and often contained apatite and more rarely diopside or olivine, and was intergrown with irregularly oriented biotite (X = pale yellow, Y = Z a red-tan colour,  $2V = 0^\circ$ ).

The mica remains absolutely fresh, but the amphibole is largely resorbed with the production of pale green diopside in the usual orientation, scattered magnetite and a little feldspar. A specimen in which the amphibole has been almost entirely resorbed is illustrated in Figure 2 D. The optical properties of such remnants of it as are determinable (see Table VI) are approximately marginal to those of barkevikite. Orthoclase, oligoclase-andesine and nepheline are the associated minerals. An originally comparable rock from Port Chalmers (C7) contains unresorbed barkevikitic amphibole with a brown rather than a reddish tint and a greenish margin indicating perhaps an approach to arfvedsonitic composition.

3. The rocks formerly termed diorite (Marshall, 1906, p. 413), but which resemble more the pegmatoid gabbro-essexite in the kaiwekite, find some analogy in the lugarites described by Tyrrell (1917). Characteristic examples (D1, D3, see Figure 2 B) are composed of large (more than 8 mm.) irregular or poikilitic basaltic hornblende ( $2V = 78^\circ$  (—);  $82^\circ$  (—),  $c \wedge Z = 4^\circ - 6^\circ$ ) with occasional parallel intergrowth of pale green diopside, faint lilac titanaugite ( $2V = 48^\circ$ ), andesine ( $Ab_{80}$ ) and natrolite with a little analcite and large ( $1.3 \times 1.0$  mm.) corroded prisms of apatite. The less coarsely granular specimens differ from lugarite collected by the writer from the type locality, in that the Scottish rock contains rather more barkevikitic amphibole ( $2V = 68^\circ - 72^\circ$  (—))<sup>\*</sup> associated with some biotite and ilmenite, which are not present in the Port Chalmers inclusions. Linking the latter with syenites is a specimen (C2, see Fig. 2 C) in which perfectly idiomorphic fresh barkevikitic hornblende ( $2V = 62^\circ - 68^\circ$  (—),  $c \wedge Z = 12^\circ$ ) unaccompanied by other coloured minerals, large prisms of oligoclase and of orthoclase (?) with some analcite lie in a rather turbid zeolitic matrix containing scattered grains of magnetite and minute prisms of apatite which are also present in the amphibole. These features are reproduced in the matrix of some lugarites. A further variation among the rocks under this head are certain other rocks at Port Chalmers (D4, D5, D6) containing masses of kaersutite, diopside ( $2V = 64^\circ$ ,  $c \wedge Z = 39^\circ$ ), labradorite and carbonate-pseudomorphs after olivine, with abundant apatite and magnetite and but little zeolite. They are very like the pegmatoid gabbros in the kaiwekite.

In some of the gabbro-essexite rocks the amphibole is marginally slightly resorbed with formation of magnetite, while within small narrow plates or prisms of rhönite have been formed elongated usually parallel to the vertical axis of the host. This change extends inwards along the cleavage-cracks in narrow bands exactly as illustrated by Tomita (1934, Plate xx, Fig. 2). The deep red ragged prisms of rhönite are up to 0.2 mm. long. (See Fig. 1 A.)

The conglomerates below the lavas of the second volcanic phase contain material derived from these breccias and various other products of the first volcanic phase. From the small exposure of these conglomerates near the head of Morrison's Creek was obtained a pebble of a peculiar trachyphonolite (735) in which phenocrysts of

<sup>\*</sup>  $2V = 52^\circ$  in the richly sodic material examined by Scott (1914) and Tyrrell (1917).

almost fresh basaltic hornblende\* (see Table VI) occur with zoned andesite, aegirine-augite and magnetite in a trachytoid matrix of oligoclase, sanidine, and minute (0.04 mm.) almost circular, weakly birefringent grains possibly leucite, together with small prisms of the coloured silicates. No such rock has been found *in situ* in the Dunedin district.

Elsewhere, particularly in Fraser's Gully, west of Dunedin, a coeval conglomerate contains pebbles of hornblendic trachybasalt (58,61) possibly derived from the above described Mornington flows, and of trachyandesite (P7, P8) derived from an unknown source. The amphibole in the latter is of two types, the yellowish variety (barkevikitic hornblende) being marginally absorbed, the reddish type (barkevikite) perfectly fresh. Their optical properties are noted on Table VI. The titaniferous character of the trachyandesite is emphasised by the presence of large (0.3 mm.) grains of perovskite. Pebbles of coesytic phonolite (P26, P45) afford another variety of brown amphibole and the only known instance of the occurrence of coesyte in products of the first phase of volcanic action in the region.

The earlier flows of the second volcanic phase are largely basaltic and rarely contain amphibole. The mineral reported to occur interstitially in the lowest of these basalts flow (No. 14) in the sequence at Otago North Head (Marshall, 1914) appears to the writer to be biotite rather than amphibole. Rocks tending to a trachybasaltic composition and containing more or less resorbed amphibole often accompanied by large prisms of dichroic apatite occur here and there among the older flows of this phase as e.g. on the south side of the Otago Peninsula opposite Ravensbourne (555) and on the western slopes of Flagstaff (522). The latter is of especial interest in that it contains a gabbroid xenolith of the type described above in which the rhönitic product of the resorption of amphibole is very well displayed (see Fig. 1 C). Near Harrington Point, by the entrance to the Harbour, a holocrystalline kulaite (691) forms a thin flow among this series of lavas, and contains abundant small resorbed phenocrysts of amphibole of which too little remains for optical study. This is part of a once rather widely extended flow of which the northern end six miles away forms the lowest of the flows at Omimi. At Brinn's Point, two miles north-east of the last-named locality, resorbed hornblende occurs either separately or enclosed in greenish diopside bordered by titanaugite forming phenocrysts in a remarkable hyalobasanite (1013, 1042).

At the base of the series of second phase flows a mile north of Port Chalmers there is a small development of trachyandesite (4834) containing xenocrystic (?) basaltic hornblende apparently derived from included pegmatoid fragments, aggregates of slender hornblende prisms both small and large varying in length up to 3 mm., the larger prisms being often prolonged into thin laminae which with the smaller prisms are more or less resorbed. In addition there are less idiomorphic stout prisms of augite and a matrix of more or less idiomorphic large and small tabulae of slightly zoned andesine containing small apatite needles, and rarely octahedra of magnetite. Sphaero-

\* Optic axial angles determined by Mr. O. D. Paterson, M.Sc.

siderite, probably deuteric, occurs in considerable amount partly replacing the plagioclase.

Higher in the series of second phase flows is the very extensive Logan's Point phonolite, described in detail by Marshall (1906) and Cotton (1908), in which brown amphibole appears in the form of coösyrite, too irregular in its development for the exact determination of its optical characters. The member of the second phase series of flows which shows the greatest development of brown amphibole is, however, the rather younger and widespread Leith Valley trachybasalt first described as andesite by Marshall (1906), from which were derived the crystals of kaersutite which have been herein studied in greatest detail. (See Tables II, III, V and VI.) The kaersutite occurs in this either (1) in fragments of coarsely crystalline pegmatoid gabbro or (2) in isolated often deeply corroded crystals up to 5 cms. long which have been obtained in particular from the Leith Valley quarries. The gabbroid rocks (e.g. 4730a) consist of basic labradorite, kaersutite, red-brown by transmitted light, pale lilac titanaugite with a faintly pleochroic greenish core, large (up to 3.0 mm.) irregular grains of ilmenite, and grey markedly dichroic apatite in prisms up to  $1.5 \times 0.2$  mm. in size, included in all the other crystals. The kaersutite when slightly resorbed shows the usual finely granular "opacitic" margin with or without rhönite. Natrolite has been formed in crevices extending out from the feldspar, and in irregular cracks between the xenoliths and the enclosing trachybasalt. Analcite may also be present, occurring as a rule in cracks or irregular spaces lined by natrolite, but occasionally forming large grains in kaersutite mantled by a thin reaction-zone of titanaugite and rhönite. The amphibole displays in different crystals dark yellow-brown or dark reddish-brown tints for Y and Z possibly depending on the degree of oxidation of the iron therein. The penetration of the enclosing trachybasalt into the coarsely granular xenoliths and the isolation of xenocrysts therefrom are visible in contact specimens. The scattered crystals of kaersutite yielded the material for analysis, the purity of which was determined by microscopic examination of partly-crushed fragments. The large crystals may be more or less idiomorphic, but are more often rather embayed by corrosion. Such absorption is not always accompanied by resorption-phenomena, for in places the amphibole is quite fresh up to the embayed margin. The optical properties of the analysed crystals and one other example have been tabulated. (See Tables V and VI.)

Resting on this trachybasalt is a phonolitic trachyandesite, the andesitic phonolite or Signal Hill phonolite of Marshall (1906) and Cotton (1908). It is nearly as widely distributed as the trachybasalt, from which it differs chiefly in the greater predominance of the colourless constituents. There are amphibole xenocrysts in it, the optical properties of which have been tabulated below (Table VI, p. 40, 445). These are as a rule distinguished by an unusually yellowish tint, and in the marginal resorption zone small grains of olivine may appear which seem to be primary rather than formed in association with the adjacent rhönite (cf. Tomita, 1934). With these may be a little calcite. Cotton (1908) concluded that the amphibole was intermediate in character between barkevikite and

basaltic hornblende, and stated that the extinction angle  $c\angle Z$  was  $15^\circ$ ; Bartrum (1911) described a large (3 cms.) crystal with the same tint as barkevikite and gave  $c\angle Z$  as  $6^\circ$ . The persistently large optic axial angle, however, betokens affinity with basaltic hornblende. It is worthy of note that Dr. Turner's universal stage measurements have shown that plagioclase crystals in clots associated with the amphibole contain bytownite (Ab30) in their central portions.

The younger phonolitic conglomerates of Pine Hill and St. Clair rest on these and contain in the former locality among a variety of other rocks, boulders of the coarsely porphyritic tinguaita in one of which was the probably barkevikitic clear brown amphibole (a borderline type) described by Ulrich (1891). (Table VI.) These conglomerates are locally invaded, interstratified with, or covered by trachyandesite, a dyke of which (144) exposed at the junction of Pine Hill and Campbell's Roads shows beautifully fresh crystals of barkevikitic hornblende. (See Table VI.)

The basalts of the third volcanic phase cover these lavas and conglomerates, and are in turn succeeded by the widespread and varied phonolitic rocks which form the latest group of flows in the Dunedin district. Those of the summit and western slopes of Flagstaff and Mount Cargill are in a large measure the olivine-bearing "trachydolerite" of Marshall (1904, 1906) and Bartrum (1911), for which a more distinctive term is not afforded by the standard nomenclature as the rock is apparently somewhat hybridised. Partially resorbed basaltic xenoliths, and clots of xenocrysts derived therefrom are scattered through the rock, and these include probably most of the very magnesian olivine present (cf. Benson and Turner, 1939). More normal cossyritic trachytoid or nephelinitoid ameleitite phonolites extend further to the north-east. Amphiboles were not rare in the "trachydolerites," though they have mostly been resorbed. Aegirine-augite and magnetite pseudomorphous after such amphiboles were described and figured by Marshall (1904, Fig. 2). More often the pseudomorph is an almost opaque aggregate of finely divided iron-ore. The original crystals are usually small and apparently phenocrystic rather than xenocrystic prisms, and rarely enclose relatively large prisms of apatite such as occur in xenocrystic kaersutite, though sometimes such apatite prisms are to be found in the ground mass of these rocks and seem foreign to it. The optical properties of one of these rarely remaining amphiboles were noted by Bartrum (44b) as those of a rather barkevikitic type, which is confirmed by the determination of the optic axial angle. There is, however, some variation in the size of the extinction angle  $c\angle Z$ . (See Table VI.) In the ground-mass of these basified phonolites finely divided cossyrite is present.

In the more richly alkaline cossyritic ameleitite phonolite, but little of the basaltic minerals appear save for the remnants of the largely resorbed magnesian olivine. Cossyrite is often very abundant in finely mossy aggregates notably in the rocks near Mopanui, but no developments of that mineral approach near enough to idiomorphism to permit a detailed determination of its optical properties. The strong bright red-brown to very dark brown pleochroism is, however, distinctive.

TABLE VI.—OPTICAL PROPERTIES OF BROWN AMPHIBOLES FROM DUNEDIN AND ELSEWHERE.

Slide No.	Rock and Crystals	Locality.	Amphibole.	X.	Y.	Z.	$e \wedge Z$	$2V (-)$	D.R.
2957	<i>Initial and First Volcanic Phase.</i> Trachy-andesite phenocryst. Groundmass.	Portobello.	Basaltic hornblende.	Light golden-brown.	Dark reddish-brown.	Darker reddish-brown.	5°	—	Med.
			Do.	Light brown.	Dark greenish-brown.	Very dark greenish-brown.	0°-2°	72°-74°	Med.
			Do.	Light brown.	Dark yellowish-brown.	Dark yellowish-brown.	5°	—	—
29	Hornblende basalt.	Mornington.	Do.	Light brown.	Dark reddish-brown.	Darker reddish-brown.	8°	—	—
4720	Inclusions in kaïwekite. Pegmatoid kaersutite	Purakanui.	Kaersutite.	Light golden-brown.	Reddish-brown.	Darker reddish-brown.	12°	—	—
D3	gabro. Pegmatoid gabbro.	North Head.	Barkevikitic hornblende (?).	Light yellow-brown.	Dark reddish-brown.	Darker reddish-brown.	11°	60°-74°	Large
L17	Nepheline "Camptonite"	North Head.	Do. (?)	Light yellow-brown.	Deep golden-red-brown.	Deep golden-red-brown.	11°	70°-82°	—
L17	phenocryst. Do. Inner portion.	Portobello.	Barkevikitic hornblende.	Straw-brown.	Dark brown.	Darker brown.	11°	68°	—
	Narrow margin. Groundmass crystals with dark greenish-brown border.		Arfvedsonitic (?) hornblende.	Pale yellowish-green.	Deep brown-green.	Deep bluish.	11°	72°	—
J24	Tingaitite porphyry (ulrichite).	Portobello.	Barkevikite.	Pale yellow.	Deep reddish-golden-brown.	Deep reddish-golden-brown.	10°-11°	60°-62°	—
J3 and J15	Nepheline syenite porphyry.	Hooper's Inlet.	Inner portion barkevikite and barkevikitic hornblende.	Pale straw yellow.	Deep reddish-golden-brown.	Deep golden-brown to brown.	9°-12°	46°-52°-68°	Med.
			Outer portion barkevikite.	Straw.	Brown.	Brown.	80°-68°	62°	—
Inclusions in O7	in <i>Rapakivi</i> . Nepheline syenite.	Harbour Cone.	Barkevikite.	Straw brown.	Clove brown.	Greenish-brown.	22°	56°-46°	Low

TABLE VI.—OPTICAL PROPERTIES OF BROWN AMPHIBOLES FROM DUNEDIN AND ELSEWHERE—*Continued.*

Slide No.	Rock and Crystals	Locality	Amphibole	X	Y	Z	c $\wedge$ Z	2V (—)	D.R.
C26	Nepheline syenite.		Barkevikite.	Straw.	Red-brown.	Red-brown.	10°		
D8	Gabbro-exsosite.	Port Chalmers.	Basaltic hornblende.	Pale brown.	Dark yellowish-red brown.	Darker red-brown.	4°–6°	78°	High
C2	Analcitised lularite.	Port Chalmers.	Barkevikitic hornblende.	Pale yellow.	Deep brown with reddish tint.	Deep golden brown.	12°	82°	
P7	Phonolitic trachy-andesite.	Fraser's Gully, Kalkorai.	Barkevikitic hornblende.	Pale yellow.	Deep golden-brown.	Deep golden yellow-brown.	8°	88°	Rather high
	Large almost fresh phenocrysts. Smaller partly resorbed		Barkevikite.	Pale yellow.	Dark brown with reddish tinge.	Dark brown with reddish tint.	20°	64°–60°	
	phenocrysts. Do. (fide Bartrum).		Do.	Do	Do.	Deep chocolate brown.		56°	
	<i>Inclusion in Second Phonolitic Conglomerate.</i>	N.E. Valley.	Basaltic hornblende.	Pale golden-yellow.	Rich brown.	Dark opaque brown.	6°	—	
	Tinguaita porphyry (fide Ulrich).	Pine Hill.	Barkevikitic hornblende (?).	Light yellow-brown.	Deep reddish-brown.	Deep rust brown.	10°	—	
	<i>Third Volcanic Phase.</i>								
144	Trachy-andesite.	Pine Hill.	Barkevikitic hornblende.	Pale yellow.	Deep reddish-brown.	Deep reddish-brown.	20°	74°	
36C	Basified phonolite or "Trachydolerite."	Mt. Cargill.	Barkevikitic hornblende (?).	Light straw brown.	Reddish-brown.	Reddish-brown.	17°	—	
44B	Phonolite.	Mt. Cargill.	Barkevikitic hornblende.	Light yellow-brown.	Deep golden-red-brown.	Deep red-brown.	5°	74°	
	<i>Brown Hornblendes in other well-known Rocks.</i>								
	Lugarite.	Ayrshire, Scotland.	Barkevikitic hornblende.	Straw brown.	Dark yellow-brown.	Darker yellow-brown.	11°	68°–72°	
	Teachenite.	Neutitschein, Moravia.	Barkevikitic hornblende.	Pale yellow.	Deep brown with reddish tint.	Deep golden-brown.	22°	74°–84°	
	Laurvikite.	Quen, Norway.	Barkevikite.	Light golden-brown.	Deep golden-brown.	Deep golden-brown.	0° (?)	63°±3°	
		Tjolling, Norway.	Barkevikitic hornblende.	Pale yellow-brown.	Reddish yellow-brown.	Chestnut brown.		76°–78°	

## CONCLUSION.

Collecting the results of the above discussion and of the data recorded in Table VI, it appears that in the Dunedin district brown monoclinic amphiboles occur very generally in the only slightly alkaline basalts and trachybasalts of the first and second volcanic phases, and prove to be basaltic hornblendes which in the two samples analysed have just sufficient content of  $\text{TiO}_2$  to permit their being classed as kaersutite. The amphibole occurs either in coarsely gabbroidal cognate xenoliths derived probably by segregation (Lacroix, 1893) at depth from such magmas, or in single grains separated from such segregations. Through processes of magmatic hybridisation such xenoliths or xenocrysts may be incorporated in a distinctly more alkaline milieu than that from which they originally crystallised. From magmas which have attained a more alkaline character, whether hybrid or derived by the ordinary processes of differentiation, increasingly alkaline sodic amphiboles may separate, namely types intermediate in character between basaltic hornblende and barkevikite, which are formed in magmas of trachyandesitic or camptonitic composition (and may subsequently appear as xenocrysts in more alkaline rocks). Definite barkevikites characterised by the possession of an optic axial angle approximating to  $2V = 60^\circ$  or less occurs in the richly alkaline nepheline syenites, tinguaites and some phonolites, and but rarely in any less sodic rock, e.g. phonolitic trachyandesite.

It should be stated that nearly all the universal stage measurements recorded herein were made by my colleague, Dr. F. J. Turner, who noted, moreover, that owing to the usual absence of minerals of which the birefringence is sufficiently definite to permit them to be utilised to determine the thickness of the rock-slices examined, it is rarely possible to give precise compensator-determinations of the birefringence of the amphiboles, and the terms high, medium and low are used in Table VI to indicate the approximate value within the known range for  $\gamma - \alpha$ , i.e. 0.021 and 0.068.

The chemical compositions of a number of the rocks mentioned in the above table may be ascertained by reference to the works cited below. Two hitherto unpublished analyses of the rocks cited, for which the writer is indebted to Mr. F. T. Seelye, are appended.

La.16, 17. Camptonite, Portobello. Analysis by Marshall (1906), p. 398.

J.24. Camptonitic tinguaita (ulrichite). See Marshall, *op. cit.*, p. 397.

J.3, J.15. Nepheline syenite porphyry. Varley's Hill, Hooper's Inlet. A rather incomplete analysis by Marshall, *op. cit.*, p. 396, and a more detailed one by F. T. Seelye (704) is given below.

C7. Nepheline syenite in breccia (?) from old shaft, Harbour Cone. For analysis by D. B. Waters, see Marshall, *op. cit.*, p. 392.

4728. Trachybasalt containing permatoïd kaersutite gabbro, Leith Valley. For a rather incomplete analysis of the host rock "andesite," see Marshall, *op. cit.*, p. 408. A more detailed analysis of part of the same flow has been made by F. T. Seelye. (See Benson and Turner, *op. cit.*, p. 71.)
445. Phonolitic trachyandesite ("Signal Hill Phonolite"). For analysis, see Cotton, 1908, p. 120.
- 36C. Basified phonolite or "trachydolerite," Mount Cargill. For analysis of a closely comparable or identical rock, see Bartrum, 1911, p. 177.
144. Phonolitic trachyandesite. Dyke, corner of Pine Hill and Campbell Roads, Pine Hill. Analysis by F. T. Seelye below.

## ANALYSES NOT HITHERTO PUBLISHED OF ROCKS CITED ABOVE

144		704	144		704	144		704
SiO <sub>2</sub>	.. 52.27	.. 51.82	H <sub>2</sub> O+	.. 3.43	.. 3.80	NiO	.. nt. fd.	.. nt. fd.
Al <sub>2</sub> O <sub>3</sub>	.. 19.92	.. 18.84	CO <sub>2</sub>	.. 0.07	.. 0.12	BaO	.. 0.09	.. 0.06
Fe <sub>2</sub> O <sub>3</sub>	.. 3.08	.. 3.71	TiO <sub>2</sub>	.. 0.62	.. 0.78	SrO	.. 0.02	.. 0.06
FeO	.. 3.48	.. 3.31	ZrO <sub>2</sub>	.. nt. fd.	.. nt. fd.			
MgO	.. 0.53	.. 0.87	P <sub>2</sub> O <sub>5</sub>	.. 0.27	.. 0.34		99.92	100.00
CaO	.. 3.71	.. 3.20	S	.. 0.02	.. 0.03	O for Cl	0.03	
Na <sub>2</sub> O	.. 6.18	.. 8.33	Cl	.. 0.11	.. 0.01			
K <sub>2</sub> O	.. 3.46	.. 3.94	Cr <sub>2</sub> O <sub>3</sub>	.. nt. fd.	.. nt. fd.			
H <sub>2</sub> O—	.. 2.46	.. 0.60	MnO	.. 0.20	.. 0.18		99.89	100.00

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## CORRIGENDUM.

Professor Speight has kindly called attention to an error in "Mineralogical Notes, No. 2"; this volume, p. 57, last sentence in the second paragraph. He has already reported the presence of quartz in one Banks Peninsula trachyte, that of Cass Peak.

**N.Z. Foraminifera: Key Species in Stratigraphy—No. 3.**

By H. J. FINLAY, D.Sc.,

Micropalaeontologist, N.Z. Geological Survey.

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THE present number is concerned with validating a large number of specific and generic names which have been in manuscript use here for new forms. Owing to the exigencies of space, the descriptions are necessarily brief and formal and usually omit details visible from figures; discussions of affinities and ranges are reserved for elsewhere. To save further space, the contraction "*CCL*, 8, 4," is used for such a reference as *Contributions from the Cushman Laboratory*, vol. 8, pt. 4; localities mentioned more than once are referred to in the text by numbers with explanatory list at the end; and size is given solely by the largest dimension, the others being mostly computable from the figures.

***Spiroplectammina steinekei* n.sp.** (Plate 24, figs. 1, 2.)

Fan-shaped, wide, with much cement. A basally jutting coil of 3-4 chambers; then about 10 pairs, slightly curved down at sides, much longer than high. Sutures limbate, depressions between flat, later concave; sides sharply keeled with a few irregular downward spines at chamber ends. Aperture small. Micro form wider with stronger sculpture, chambers of more regular height, small initial coil. Size, 1.2 mm.

Type from 5301. Index of Lower Rakauroa and Whangai.

***Spiroplectammina piripaua* n.sp.** (Plate 24, figs. 3, 4, 6.)

Smooth, somewhat shining, mostly cement. Shape a keeled cone, width increasing at about 50°, thickness 45°. A prominent coil of 3-4 chambers; then about 5 pairs, 4 times long as high, sloping at 30°. Keel acute to last chamber. Sutures darker, not limbate. Aperture long, narrow. Micro form with sharp apex and about 8 pairs chambers. Size 1.0 mm.

Type from 5664. Index of Piripauan. Differs in sculpture, texture, end-shape, and aperture from *steinekei*.

***Vulvulina jablonskii* n.sp.** (Plate 24, figs. 7, 8, 13.)

Like *penmatula* and *italica* as figured by Cushman (*CCL*, 8, 4, pl. 10; 1932); with wide, low uniserial chambers and deep grooves between as in *italica*, but even narrower in both micro and macro form; with a spine at ends of chambers like *pacifica*. The boomerang-shaped terminal chambers, with strong angle and tiny aperture resemble only the Recent *arenacea* (Bagg), topotypes of which show blunt keel and no spines and are certainly not *Ammospirata* as Cushman suggested (*CCL*, 9, 2, p. 32; 1933). Size, 3 mm.

Type from 1193, Poverty Bay (Patutahi S.D., Mangatoetoe Stream); basal Tutamoe. Index of this and part of Ihungia (i.e. Middle Miocene). Differs in aperture and end-shape from all our other species.

A somewhat related form, *Vulvulina bünongi* n.sp. (Plate 24, figs. 9, 10), from the Whangai of Hawke's Bay, is of interest as being the only Cretaceous *Vulvulina* known here (or elsewhere?). It differs from *jablonskii* in practically smooth surface (coarse, close grains in much cement), feeble spines, much greater thickness (end face flatly convex) and sub-horizontal anterior outline, without angle at middle, but with small, oval aperture; size 1.4 mm.

*Siphotextularia acutangula* n.sp. (Plate 24, figs. 14, 16.)

Test of fine cement, no visible grains; six pairs of chambers, flatly convex, rapidly increasing in height and thickness. Lower half with sharply keeled sides; later chambers increasingly flatly rounded on top. Sutures shallow, but well marked anteriorly. Aperture central, elongate, curved, oval, above base of chamber and with a lip all round. Differs from other New Zealand species in sharp, erect carina. Size, 1.7 mm.

Type from 5459, Dannevirke area (Mangaotere S.D., 178 chs, at 74° from Trig U). Index of Upper Bortonian, Wanstead facies.

*Siphotextularia wanganuia* n.sp.

Differs from *S. wairoana* Finlay, 1939 (*Trans. Roy. Soc. N.Z.*, vol. 68, pt. 4, p. 511, pl. 68, figs. 2 a, b) only in larger and longer test with more chambers (about 8 pairs) and less rhomboid habit, front flattish instead of deeply hollowed, sides slightly convex instead of flat. Size, 0.9 mm.

Type from 5216, Mid-Castlecliff beds, Wanganui. Apparently limited to this Upper Pliocene horizon.

*Hauserella hectori* n.sp. (Plate 24, figs. 11, 12, 20.)

As large as or larger than *pukeuriensis* Parr, 1935 (*Trans. Roy. Soc. N.Z.*, vol. 65, pt. 2, p. 83, pl. 19, figs. 7 a, b), but never reaching a uniserial or even staggered stage. In this it is like "*Bulimina*" *textulariformis* Stache and *arcuata* Stache (which are synonyms) from the Mid-Oligocene Whaingaroan (*Novara Pal.*, vol. 1, pp. 268-269, pl. 24, figs. 17-18; 1864), but is almost twice as large, somewhat stouter, and has deeper sutures. It has same tendency to incorporate elongate grains in a particular direction (lost in later species) and would be regarded as a sub-species were it not a convenient marker for beds of "Lower Hutchinsonian" age, before *pukeuriensis* develops in true Hutchinsonian and Awamoan. Size, 2.7 mm.

Type from 5385, All Day Bay (greensands with *Pachymagas*, above basal conglomerate, below *Waiparia* zone).

Pliocene end point of lineage is reached with *Hauserella parri* n.sp. (pl. 24, fig. 5); more compressed than any of the others, with sides more strongly angled (over most of length), still large, with biserial stage occupying three-quarters or more of length, and a few staggered uniserial chambers, sutures weak. Type from 4337, Hawke's Bay (Eskdale, Tutira, 2 m. from Makomako turn-off); size 1.4 mm. Range Opoitian-Nukumaruian; in lower part with *Bigennerina pliocenica*, which differs in rougher texture, proportion of biserial part and non-staggered chambers.

***Bigenerina pliocenica* n.sp.** (Plate 24, fig. 15.)

Coarsely arenaceous, little cement, very rough. Biserial part roundly compressed with blunt-angled keel and 5-6 chamber pairs. Uniserial chambers sudden, cylindrical, 3 to 4. Aperture small, central, with ragged edges. Sutures obscure on early half, deepening later. Size, 1.3 mm.

Type from 2058, Poverty Bay (Opoiti S.D., Makaretu River, 30 chs. E. Trig. R4), where more and better specimens were found after the paratype (G.S. 706, Clyde; Waitotaran) had been figured. Index of Opoitian and Waitotaran. Related to *B. speciosa* Yabe and Asano, 1937 (*Sci. Rep. Tohoku Imp. Univ.*, Ser. 2, vol. 19, no. 1, p. 97) from West Javan Miocene, but half as large, less compressed, feebler sutures. Common in Westland Upper "Blue Bottom" (5711).

***Gaudryina whangaia* n.sp.** (Plate 25, figs. 29-31.)

Small, elongate, slender, whitish, of fine sandgrains in excess cement, surface smoothed. Triserial part a third or more of length, sides a little concave, angles at first sharp, rapidly blunted by globose chambers (5 distinct); biserial part twisted, chambers 4-5 pairs (last flatly globose), little increasing, sutures subhorizontal, shallow but distinct, end face at about 40° with very small round aperture at base. Size, 1.2 mm.

Type from 5374. Index of this horizon, probably Upper Piri-pauan. Common in Whangai and mid-Rakauroa; always present in two forms, smaller (megalo) only half size or less, with fewer triserial chambers and blunter apex, otherwise same as larger.

***Gaudryina healyi* n.sp.** (Plate 25, figs. 34, 35.)

Coarsely arenaceous, much cement, but rough surface. Triserial part about one-third of length, sides faintly concave, angles a little blunted. Biserial chambers about 3 pairs, convex, with posterior blunt angle, anteriorly flatly rounded and smoother, sutures furrowed but not distinct. Terminal face sloping at 45°, the basal elongate-oval aperture one third as wide and half as high, with surrounding blunt angulation. Size, 1.4 mm.

Type from 5664, Piripauan. Common here and in equivalent Lower Rakauroa of Poverty Bay (3249, 3270, 3242, etc.). Doubtfully present in Hawke's Bay, or in Whangai and Upper Piripauan anywhere. Differs from European *rugosa* d'Orb. in deep sutures and subangled chambers.

***Gaudryina reliqua* n.sp.** (Plate 25, figs. 32, 33.)

Same general type as *healyi*, but smaller, much more quadrate, with flatter sides, shallow sutures, and shorter chambers, much flattened anteriorly; terminal face much shorter, at angle of 30°; aperture short, narrow. Size, 1 mm.

Type from 5338; lowest Bortonian (as in mid-Waipara section—5671, 5672; below Lower Bortonian of Hampden section). Only seen here, from lowest Te Hua marls of Whangara, and from base of Amuri limestone at Kaikoura Peninsula. Blunter angles than the related Cuban Eocene *G. rutteni* Cush. and Berm., 1936 (*CCL*, 12, 3, p. 56, pl. 10, figs. 15, 16) which Cushman (*CCL*, Special Pub. No. 7, p. 90; 1937) puts in *Pseudogaudryina*; they seem less like *atlantica* Bailey than *rugosa* d'Orb.

***Pseudogaudryina anachrons* n.sp.** (Plate 25, figs. 36, 37.)

Very similar to *reussi* Stache, differing only in rougher surface (sandpaper texture instead of smoothed off) and prominent angles, more pinched into ridges and especially continued over whole shell; *reussi* has last 2-3 chambers globose and rounded and normally Gaudryine; *anachrons* has bi-angled terminal chamber and a Verneulinine shape; size, 2.5 mm.

Type from 5683, Weka Pass stone, mid-Waipara; Duntroonian. This is the form I recorded as *reussi* (*Trans. Roy. Soc. N.Z.*, vol. 69, pt. 1, p. 93; 1939) from the basal "Grey Marls." *G. reussi* ends with Whaingaroan, this marks the Duntroonian (though absent in Waitaki area) and basal zone of overlying "Grey Marls" (Weka Pass, Lower Motunau and East Grey). Also in lowest "Blue Bottom," just above Cobden limestone (5713). Triangular form recalls Bortonian *proreussi* Finlay, which has much sharper angles, fine texture, longer lower aperture.

**MIGROS n.gen.** (Fam. Verneulinidae).

Genotype: *Gaudryina medwayensis* Parr (as here figured and interpreted).

Identical with *Gaudryina* in all respects, except that aperture has entirely migrated into terminal face, but remains connected with base of last chamber by narrow groove-like channel, formed by incomplete closing in of sides. This is already evident in quite young shells, which even in triserial stage show a small, high, rounded aperture unlike true *Gaudryina*. A uniserial stage is approached, but never quite attained. This is to *Gaudryina* what *Haeuslerella* (especially the species *hectori*) is to *Textularia*.

***Migros medwayensis* (Parr).** (Plate 25, figs. 38-40.)

1935. *Gaudryina medwayensis* Parr; *Trans. Roy. Soc. N.Z.*, vol. 65, pt. 2, p. 83, pl. 20, figs. 2 a-c.

Parr described this from the South Island Medway River as an Awamoan form closely related to *reussi* Stache. But *Bolivinita* and *Massilina subaequalis* (Parr) demonstrate a Taranakian age (probably Tongaporutuan), while the *reussi* line disappeared in the Oligocene and is not related. Parr's poorly preserved type shows (more than does his figure) this apertural migration, the opening and groove being filled with matrix. Better specimens are here figured from G.S. 1342, where it is common; size 1.8 mm. It has not yet occurred below this Tutamoe horizon, but ranges up to Lower Taranakian (3140, etc.). Identification with Parr's species is practically certain, but if any future discrepancy should occur the genotype of *Migros* is to be taken as the Poverty Bay form here figured. The Recent *fintii* Cush. (see Cushman, *CCL*, Special Pub. No. 7, pl. 10, f. 18-20) is congeneric and probably also *tenuis* Cush.

***Eggerella decepta* n.sp.** (Plate 25, figs. 24, 25.)

Coarse grained with little cement, surface rough, chambers globular, flattened at 45° on top, rapidly increasing, 4 on each bluntly rounded angle, apex flatly rounded, early chambers obscure, all appearing triserial, sutures well marked only on last coil, strongly marked on end face, aperture at their intersection, small, rounded. Size, 0.8 mm.

Type from 5338; Lowest Bortonian. Seems an index species of this age, but common only at type locality; when crushed easily mistaken for distorted *Haplophragmoides*. No evidence observed for more than triserial chambering; referred to *Eggerella* simply because unlike any described *Verneuilina* and differing only in more detached chambers from such Eocene forms as *Eggerella cushmani* (W. and A.) and especially *palmerae* (Cole).

***Dorothia biformis* n.sp.** (Plate 25, figs. 26–28.)

Fine sand grains, rather distantly set in much cement; surface quite smooth. Micro form large, conic, tapering to point; chambers obscure (sutures faint), 3 biserial pairs forming three-quarters of length, last chamber very wide, with narrow, curved, terminal face carrying long linear aperture at base. Megalo form sub-cylindrical, much less tapering, with blunt apex and better defined, fewer chambers, aperture much shorter. Size, 1.7 mm. (megalo), 1 mm. (micro).

Type from 5664. Common in Piripauan and Lower Rakauroa; presence in Whangai uncertain. Somewhat like Oligocene *eurystoma* variety of *karreri* (Stache) (which is indistinguishable in practice from the Hutchinsonian-Awamoan *minima* Karrer), but not near any species figured by Cushman (CCL, Special Pub. No. 8, 1937).

***Dorothia agrestis* n.sp.** (Plate 25, figs. 41, 42.)

Coarsely irregular grains with little cement; surface very rough. Triserial chambers obscure, about a third of length, then about 4 biserial. Sutures merely indicated; terminal face at angle of 45°, with large rounded aperture at base. Size, 1.2 mm.

Type from 5540, Lower Bortonian; also at Waihao Downs (G.S. 1988). Index of this horizon; similar rough forms in Upper Bortonian being always *Plectina* or *Arenodosaria*.

***Plectina quennelli* n.sp.** (Plate 24, figs. 17–19.)

Fine sand grains, closely set in much cement, surface smooth; a little tapering; greatest width at second last chamber. Triserial part half length (sutures weak), two biserial and a final globose chamber with small, round latero-terminal aperture (sutures barely distinct). Size, 1.1 mm.

Type from 5339, Dannevirke area (Porangahau S.D., 202 chs. at 80° from Trig. U). Index of Upper Bortonian, Wanstead facies. Near *P. torrei* Cush. and Berm., 1936 (CCL, 12, 3, p. 57, pl. 10, figs. 12–14), but larger, with early chambers less swollen and weaker sutures. In the Upper Bortonian (5179B, Hampden; 1014, Poverty Bay) is *Plectina agrestior* n.sp., a form with rough surface, little cement, wide shell, few and inflated chambers, deep sutures and small circular aperture (type from 5606, Chalk Marl, Mount Highfield). Size, 1.3 mm.; it is a replica of *Dorothia agrestis* Finlay, except for aperture.

Genus MATANZIA Palmer, 1936.

This seems available for forms externally like *Dorothia*, internally with partitions like *Textulariella*. Cushman (CCL, Special Pub. No. 8, p. 102; 1937) mentions only the Cuban Oligocene genotype, *bermudezi* Palmer, but two of the species he refers to *Textulariella*,

*miocemica* Cush. (*l.c.*, p. 63) and *magdalidiformis* (Schwag.) (*l.c.*, p. 66) seem referable here—compare Cushman's figures pl. 7, f. 10, and pl. 14, f. 17. These stand out from the concave topped *Textulariella* group, from which *Matanzia* is separable exactly as *Dorothia* is from *Marssonella*. Whether the partitions reach the centre of the test is probably variable; in the accompanying *Cubanina* some of them do.

***Matanzia simulans* n.sp.** (Plate 25, figs. 21–23.)

Externally very like *Dorothia bifurcata* Finlay, same duality of shape, though micro form less elongate. Sutures deeper and much clearer. Chambers shorter, more globose, flattened on top and with dorso-lateral bevelling. Aperture smaller. Interior structure usually distinct, especially on moistening. Size, 1.3 mm. (micro).

Type from 5374. Rather common in Whangai beds; also in mid-Rakauroa (3250A) of Poverty Bay, but not seen in Tapuwaeroa or Piripapan. Undoubtedly congeneric with *miocemica* Cush., but has fewer chambers and deeper sutures. This is the first Cretaceous species, and may be derived from *Hagenowella*. Another species is *Matanzia mahoenuia* n.sp. (type from 5710, Lower Mahoenui, 2 m. from Aria); quite close to the genotype, but much smaller (max. size 1.1 mm. instead of 1.8 mm.), stouter, with sloping terminal face and very narrow vertically compressed aperture; much resembling *Dorothia hayi* (Karrer) in general habit.

***Robulus dorothiae* n.sp.** (Plate 27, figs. 107, 108.)

Small, flattened, with sharp carina and small flange, about 12 chambers per coil, those of last flatly bevelled at about 30°, those of previous coil flat, early coils obscured by shallow umbonal pit surrounded by faint thickening. Sutures slightly limbate, directed back at 30°. Aperture normal with strongly projecting small lips. Size, 0.8 mm.

Type from 5390, Poverty Bay (Rotokautuku Creek); Middle Ihungian, i.e. true Hutchinsonian. Not uncommon in equivalent beds of the Mahoenui and South Island "Blue Bottom." One of our most characteristic species of *Robulus* in its central hollowed flattening and lateral bevel.

Genera PALMULA, FRONDICULARIA AND "VAGINULINA."

The Cretaceous *Lagenidae* here described so much resemble well-known species that to save space they are described by comparison. In spite of the many European names given to like forms, these species have short ranges in New Zealand and disagree with the clear figures given by Cushman, so are best treated as distinct.

***Palmula rakauroana* n.sp.** (Plate 26, figs. 51, 52.)

New Zealand representative of the European Uppermost Cretaceous and American Navarro *reticulata* Reuss, but narrowly rhombic in form (consistent in all specimens seen), base not spreading and chambers not extending back. Initial Flabelline part much reduced, hardly visible; proloculum relatively enormous with 5–7 heavy ribs; this simulates *Frondicularia*, but ornament and chambering identical with *Palmula reticulata*; a microspheric specimen would probably show initial coiling better. Size, 3.0 mm.

Type from 3270, Poverty Bay; also in 3242 and 3249, similar beds nearby. Also in 5664, type Piripauan, indicating, with many other species, correlation of these horizons.

***Palmula thalmani* n.sp.** (Plate 26, figs. 53, 54.)

Apparently quite close to the Trinidad Upper Cretaceous *semi-reticulata* Cush. and Jarv., 1928 (*CCL*, 4, 4, p. 98, pl. 13, fig. 4). Same reticulate network, less regular than in *reticulata*, but nothing like the strong pits and raised ridges of the Trinidad form; only the Flabelline part has strong, irregular, anastomosing ridges; rest of surface has a rather finely honeycombed effect, the tiny elongate (oblong or polygonal) chamberlets separated by hairlike ridging, hardly raised above surface. At apices of successive chambers is a conspicuous formation of multiple loops, as in the Trinidad *jarvisi* Cush., which is otherwise quite different. Size, 1 mm.

Type from 5301, probably Whangai. Several examples found here; seen elsewhere only in equivalent beds from Whangara uplift, Poverty Bay.

***Palmula rugosa* (d'Orb.).** (Plate 26, fig. 57.)

Illustrated specimen is from 3249, Poverty Bay, an Upper Piripauan (Campanian?) horizon; a single example is also known from 5300A, Dannevirke area. All specimens fragmentary with intra-sutural spaces obscured by matrix, but the characteristic raised papillae seem definitely visible.

***Palmula bivium* n.sp.** (Plate 26, fig. 59.)

1926. *Oristellaria cassis* F. and M. sp. Flabelline variety. Chapman, *N.Z. G.S. Pal. Bull.* 11, p. 59, pl. 12, f. 9; *non* F. and M.

Chapman thus figured from G.S. 595, Moeraki Peninsula (*i.e.*, Upper part of Hampden section) an index Upper Bortonian form; it occurs often in this area, while *P. marshalli* (Chap.) (*l.c.*, p. 66, pl. 13, figs. 6, 7) seems limited to a narrow zone in the Hampden Upper Bortonian. *P. bivium* has very prominent coiled stage with about 6 chambers and heavily noduled raised sutures, 6–7 high-arched uniserial chambers also with limbate but less nodular sutures, sides sharply carinate (except truncate end faces) with broad jagged flange round coil; size 2.8 mm. A Tahuian descendant, ***Palmula bensoni* n.sp.** (type from 5068, Burnside Marl) differs only in thick shell with sides truncate, much feebler coil with only small flange and more acutely angled later chambers; size, 2.8 mm. *P. marshalli* is a large spreading shell of about 12 uniserial chambers and a small globular coiled part, without sculpture except obsolete ribs (8–9) on first few chambers, stronger on swollen proloculum, sides rounded, coil with a sharp medial narrow keel. It, too, has a descendant, ***Palmula taranakia* n.sp.** (type from 1242, Awakino R.; Whaingaroa), which is thinner and much smaller, the 12 chambers consequently narrower, more arched, sides a little carinate with often some irregular basal spines, sculpture quite obsolete except for a few wrinkles on the strongly spiked proloculum; size, 3 mm.; not common, but fragments in both Whaingaroa and Mahoenui beds, also South Island "Blue Bottom."

**Fronicularia teuria** n.sp. (Plate 26, figs. 60, 61.)

New Zealand representative of such types as *dimidia* Bagg, *arkadelphiana* Cush., and especially *frankei* Cush. Differs from all these in having ribs irregularly continuous over whole surface, overriding obscure chambers and sutures. Chambers high as in *dimidia*; proloculum with about 6 heavy costae continuing into finer adult ribbing; ribs diverging and running out towards sides throughout shell, new ones intercalated by bifurcation; sides almost parallel, angle very slight. Size, 1.7 mm.

Type from 5301; also from several localities in the Te Uri Cretaceous section, and two fragments from the Poverty Bay mid-Rakauroa, 3250A—these are all Whangai.

**Fronicularia steinekei** n.sp. (Plate 26, fig. 62.)

Differs from *teuria* only in larger and thicker shell, with distinct medial blunt subangulation instead of flat surface, and with ribs running evenly over whole surface without bifurcating and directed slightly inwards towards centre, instead of out to sides. It is also from an older horizon. Size, 2.5 mm.

Type from 3270, Poverty Bay. Not yet seen elsewhere.

**Fronicularia mucronata** Reuss. (Plate 26, fig. 58.)

The specimen here figured is from 3250A, Poverty Bay mid-Rakauroa; a few other broken examples have been found (3249, 5301) all at about this horizon. The shell is fairly thick, with truncate sides and slightly raised sutures. From the little material available there seems no way of separation from *mucronata* as figured by Cushman, 1936 (*CCL*, 12, 1, p. 15, pl. 3, figs. 16, 17), but better specimens may show differences, for the American material is all from the much lower Austin and Taylor.

## Genus PLANULARIA DeFrance, 1824.

The monotype of this genus, *Nautilus auris* Fichtel and Moll, has been discussed by Cushman; his figure and description (*CCL*, 7, 3, p. 71, pl. 9, fig. 16; 1931) are of a shell quite unlike the conventional interpretation of *Planularia*—for such spreading Lenticuline forms as *advena* C. and J. figured as example by Cushman (*Illustrated Key*, pl. 20, fig. 7)—but it is quite like such a Recent form as *Vaginulina patens* Brady and many Cretaceous forms conventionally referred to *Vaginulina* (see, for example, such forms as *intumescens* Reuss, etc., figured by Cushman and Alexander, 1930; *CCL*, 6, 1, pls. 1 and 2). These are not in the least like *Nautilus legumen* L., the Recent type of *Vaginulina*; this lineage does, however, extend back to the Cretaceous in such forms as *taylorana* Cushman (*l.c.*, 14, 2, pl. 5, fig. 19), whose generic separation from such other forms as "*Marginulina*" *silicula* (Plummer) (*l.c.*, 13, 4, pl. 14, figs. 19–22) seems artificial. I would prefer to break up these artificial groupings and associate the Cretaceous *kochii-simondsi* group with *Planularia auris*. Marie has recently (*Bull. Soc. Geol. de France*, ser. 5, vol. 8, nos. 1–2, p. 93; 1938) discussed and figured a number of French Cretaceous species of this group, using the genus name *Citharina* d'Orb., typified by *Vaginulina striatula* Roemer. This is undoubtedly

a correct usage of d'Orbigny's name, which, however, did not appear till 1839, and I incline to agree with Galloway (*Manual*, p. 240; 1933) in merging it with the earlier *Planularia*.

***Planularia whangaia* n.sp.** (Plate 26, figs. 63–65.)

New Zealand representative of the American Navarro *simondsi* Carsey, but differing considerably in shape, tapering much less posteriorly; chambers much more numerous and very narrow, suture lines more raised above surface than transverse ribbing, which is very fine, dense and regular, with no sign of the basal stronger costae of *simondsi* or peripheral tricarination. There is considerably more resemblance to a form from the Californian Moreno Shale, figured as cf. *simondsi* by Cushman and Campbell (*CCL*, 11, 3, pl. 11, fig. 7), but an actual specimen shows different outline and striation. Size, 1.2 mm.

Type from 5665, Mid-Waipara, Upper Piripauan; also from East Grey (5329), Dannevirke area (5301), Hawke's Bay (Te Uri section), and Poverty Bay (3249, 3250A). Typical of Whangai, but probably extends lower.

***Planularia rakauaroa* n.sp.** (Plate 26, figs. 66, 67.)

Similar in general style to *whangaia*, but sheath-shaped; larger and much more elongate, with subparallel sides over most of shell, which is thickened medially and has convex instead of flat surface; sutures thicker, wider than chambers instead of narrower as in *whangaia*. In general details very similar to *suturalis* Cush., 1937 (*CCL*, 13, 4, p. 102, pl. 15, figs. 5–7) of Upper Taylor; costae similarly developed only on sutures, but even more parallel sides and narrower, more numerous chambers. Size (restored), 2.3 mm.

Type from 3250A, mid-Rakauaroa. Also from equivalent Waipara greensands (5666) and Lower Rakauaroa of Poverty Bay (3242, 3249, 3270).

***Marginulinopsis marshalli* n.sp.** (Plate 26, figs. 47, 48.)

Initial coiled part obscure, of about 4 lightly convex chambers with linear sutures hardly raised; about 6 later chambers separated by heavily limbate sutures much thicker on medial half of surface; no other ornament; all sides except terminal face sharp with narrow flange all round hardly interrupted by coiled portion. Size, 1.2 mm.

Type from 5540. Index of Lower Bortonian. Replaced by noduled forms in higher beds (*hochstetteri*) and in still lower beds (*waiparaensis*). Present in part of Poverty Bay Te Hua beds (4005, Waitangi Stream), and in East Grey Stream (5328, mudstone under Upper Bortonian sands below Amuri limestone).

***Marginulinopsis waiparaensis* n.sp.** (Plate 26, figs. 45, 46.)

Similar to *marshalli* in size and convexity, but with nodular sculpture; coil more prominent and projecting, heavily ribbed in megal form; chambers up to 9, with narrower sutural ridges, not thickened medially, broken up into 6–7 nodules, a second carina on each side of peripheral one, the narrow flanges irregularly serrate. Size, 1.8 mm.

Type from 5672, lower part of sandy marl below Amuri chalk marl, mid-Waipara; index of lowest Bortonian, replaced in upper part of same sandy marl (5673, 5675) by *marshalli*, and in uppermost

part (5675) by *hochstetteri*. Also from Dannevirke area (5338) with *Gaudryina reliqua* and in identical fauna from base of Amuri limestone at Kaikoura. *M. hochstetteri*, here illustrated from Hampden Upper Bortonian (5179B) (Plate C, figs. 49, 50), is a much larger, more spinous and compressed form with far more chambers; size over 3 mm.; originally described from the Whaingaroan, its upper limit.

Similar forms are widespread in Middle and Lower Eocene; compare *asperuliformis* Nuttall from Mexico and French Morocco, and the forms of *fragaria* Gumbel (e.g. *texasensis* C. and A., etc., from Californian Capay).

***Marginulina allani* n.sp.** (Plate 26, figs. 55, 56.)

Stout, cylindrical, hardly tapering initially, blunt, about 3 slightly curved chambers (microspheric initially carinate), followed by 5 rectilinear, little increasing, sutures at first flush, gradually deepening, whole surface covered by vertical low ribs, own width or less apart, 16-20 each side, continuous across sutures in a slightly sloping direction, terminal face becoming smooth, with large circular spout aperture (typically serrate) a little to one side. Size, 2 mm.

Type from 5655; Waitakian. Belongs to the group of *costatus* Batsch, but is not at all like Cushman's figures of topotypes (CCL, 7, 3, pl. 8, figs. 4, 5); this line seems to begin here in the Whaingaroan.

***Sigmoidella bortonica* n.sp.** (Plate 25, figs. 43, 44.)

Close to the Recent *elegantissima* (P. and J.), but outline more heart-shaped. Instead of "almost circular excepting the slightly acute apertural end" (as Cushman and Ozawa state for *elegantissima*), it is more convex in lower half of outline, upper half having sides flat or faintly concave, producing a sharp projecting apex. Basal margin distinctly hollow medially; outer chambers flatly hollowed each side, margins sharp; same number of chambers visible but differently disposed. Size, 1.1 mm.

Type from 5540. Though never common it occurs at several Lower Bortonian localities, and seems to be an index species; the genus is apparently absent in higher beds, until the Hutchinsonian of Clifden, whence *elegantissima* and *kagaensis* have been reported by Parr and Collins, 1937 (*Proc. Roy. Soc. Vict.*, vol. 50, N.S., pt. 1, p. 206). The genus is not known from the Cretaceous, but appears in the Midway.

**Genus ARAGONIA n.gen.** (Fam. Heterohellicidae).

Genotype: *A. zelandica* n.sp.

Resembles *Bolivinoidea* in the tendency to thicken anteriorly, but with sharp carina at least on early half, and feebler ornament of quite different type; habit resembling *Textularia* rather than *Bolivina*. Aperture small, horizontal, rounded, without tooth.

I suggest the following as congeneric: *Textularia aragonensis* Nuttall, 1930 (*Journ. Pal.*, vol. 4, no. 3, p. 280, pl. 23, fig. 6—Mexican Lower Eocene), *Bolivina capdevilensis* C. and B., 1937 (CCL, 13, 1, p. 14, pl. 1, figs. 49, 50—Cuban Eocene), *Bolivina monilifera* G. and M., 1931 (*Journ. Pal.*, vol. 5, no. 4, p. 349, pl. 40, fig. 3—Mexican late Cretaceous ?), *Textularia velascoensis* Cushman, 1935 (CCL, 1, 1,

p. 18, pl. 3, fig. 1—Mexican Upper Cretaceous), and *Bolivinoidea trinitatensis* C. and J., 1928 (*CCL*, 4, 4, p. 99, pl. 14, fig. 10—Trinidad Upper Cretaceous).

***Aragonia zelandica* n.sp.** (Plate 27, figs. 68, 69.)

Closest to *aragonensis* Nuttall, with similar shape and encircling sharp keel (but also with narrow flange); same narrow sutural ridges but no fine raised projections between, aperture a narrow, raised slit along base as in *velascoensis*, prohibiting reference to *Bolivina* or *Bolivinoidea*. Size, 0.3 mm. Type from 5319, Dannevirke area (Mangaotero S.D., 111 chs. at 118° from Trig. U); index of Upper Bortonian, Wanstead facies.

***Bolivinita pohana* n.sp.** (Plate 27, figs. 99, 100.)

Shell differing from *quadrilatera* Schwager in considerably greater compression and obliquity (compressed rhomboid in section, instead of squarish), blunter and unflanged keels, simple proloculum, presence of a few ridges at sutures on sides and much smaller aperture, occupying half of terminal face instead of nearly all. Size, 1.5 mm.

Type from 3137, Poverty Bay (Kaiti Beach section, 100 ft. above *Ammodiscus* bed); horizon Lower Poha, i.e., Tongaporutuan.

This *quadrilatera* lineage is the index marker for inception of Taranakian in New Zealand; the present species is commonest and longest ranging, coming in suddenly in abundance at base of Poha and lasting into Opoitian. The side ridges are too marked in the figure; they are feeble and mostly obsolete, the micro form especially being without sculpture. Characteristic of the Pliocene is ***Bolivinita pliozea* n.sp.**, differing from *pohana* in having hardly any obliquity and very convex sides, with 3–5 sharp linear equidistant ridges between the main keels, which are much closer together and enclose a deeply hollowed medial smooth area. Type from 5214, Castlecliff beds; common throughout almost all Pliocene, but rare in Opoitian, where dominant form is still *pohana*, which lasts into Nukumaruan.

A related species in somewhat higher beds is ***Bolivinita compressa* n.sp.** (plate D, figs. 101, 102), type from 5018 (near top of type Poha section, Hangaroa Stream); it differs in wide extremely compressed shell (one side angle running almost up middle of front), absence of sculpture on sides, and slightly flanged keels; size, 1.4 mm.

***Plectofrondicularia awamoana* Finlay.** (Plate 27, fig. 109.)

1939. *P. awamoana* Finlay, *Trans. Roy. Soc. N.Z.*, vol. 69, pt. 1, p. 100.

The All Day Bay holotype is here figured. Another multi-ribbed species is ***Plectofrondicularia fyfei* n.sp.** (plate 27, fig. 110), close to the Pliocene *pellucida* Finlay (*l.c.*, p. 99, pl. 2, fig. 7), but larger and thicker, sharply carinate, with ribs raised and much coarser, angle of sutures much wider (over 90° instead of about 70°); size, 1 mm.; type from 5557A (Cheviot Grey Marl, 30 chs. S.W. of Trig. Sub Y; Tongaporutuan); probably an index of Taranakian age.

**Zeauvigerina parri** n.sp. (Plate 27, figs. 70, 71.)

Differs from Upper Bortonian *zelandica* Finlay, 1939 (*Trans. Roy. Soc. N.Z.*, vol. 68, p. 541, pl. 69, fig. 4) only in primitive character; conspicuous tube aperture practically absent, only a short unrimmed neck appearing, surface but slightly roughened, dense pustules of *zelandica* being absent. Appears by itself in Lower Bortonian and remains present with *zelandica* in the Upper, the smooth and pustuled shells being easily separable. They were originally thought to be micro and megal forms, but the constant finding of *parri* alone at many Lower Bortonian localities prohibits this; size, 0.27 mm.

Type from 5280, Dannevirke area (Motuotaraia S.D., 225 chs. at 273° from Trig. 21), with abundant *Globorotalia crater* Finlay.

**Bolivina anastomosa** n.sp. (Plate 27, figs. 75-77, 103, 111.)

Small, wide, at first thick and blunt, later compressed to sharp edge, chambers numerous, hidden by sculpture on first half, about 3 on each side visible on latter half, sutures limbate in patches which mark base of previous apertures, early half with heavy sculpture of anastomosing ribs, a medial and 1-2 side ribs stronger, latter half without this sculpture, aperture tiny. Size, 0.5 mm.

Type from 5273. The species is ubiquitous and extremely abundant throughout our Middle Tertiary, appearing suddenly in the Kaiatan. It corresponds to the American *byramensis* Cushman and especially the European *reticulata* Hantken and Egyptian *retiformis* Cushman, but differs in sculpture details. In the basal Kaiatan of Bridge Point (5244, Green tufts below Oamaru limestone) is *Bolivina pontis* n.sp., the first appearance of this line, differing from *anastomosa* in much more open network with no intermediate sculpture, the vertical lines mostly not reaching upper suture.

*Anastomosa* has not been seen above Awamoan; very similar forms common in Taranakian and Lower Pliocene are initially compressed, with a small sharp flange all round and small proloculum, thus lacking the blunt, swollen appearance. These are related to *robusta* Brady (which is swollen and has a spine), and may be called *Bolivina affiliata* n.sp., the type being from 5703, Upper Blue Bottom, Westland, a Taranakian horizon. The two species occur together in the Awamoan Middle Blue Bottom (5707).

**Rectobolivina maoria** n.sp. (Plate 27, figs. 82-84.)

A species with few uniserial chambers and a heavy surface ornament slightly recalling the Recent Indo-Pacific *Siphogenerina dimorpha*, but much more like the Australian Janjukian *victoriensis* Cush., 1936 (*CCL*, Special Pub. No. 6, p. 53, pl. 7, figs. 18 a, b); surface densely punctate, with translucent appearance, heavily wrinkled by sutural lobation; a medial sutural tongue more pronounced, with one on each side; chambers about 3 biserial pairs in first half, about 3 uniserial in last half, which tends to become cylindrical, sides bluntly rounded; apertural terminal without lip. Size, 0.53 mm.

Type from G.S. 1342. Common throughout our Miocene, entering suddenly in Hutchinsonian. The Australian form is less medially depressed, more coarsely punctate, and lacks uniserial chambers.

A related form is *Rectobolivina maoriella* n.sp. (plate 27, figs. 78–81); this differs only in smaller size, much more slender form with later chambers staggered rather than regularly uniserial, with posterior surface more wrinkled by fine ridging, and with sutural lobation feeble. Frequently occurs with *maoria*, but is not the megalos form; more common in the South Island; apparently extends lower in Hutchinsonian, and doubtfully as high as Taranakian. Type from 5273; size, 0.4 mm. The end point of *maoria* is Opoitian (rare).

*VIRGULOPSIS* n.gen. (Fam. Bulminidae).

Genotype: *V. pustulata* n.sp.

Test small, calcareous, finely perforate, strongly built and compact, compressed-cylindrical, biserial for nearly whole shell, but with small initial triserial part and blunt apex, heavily sculptured by irregular plicae and pustules, aperture large, Loxostomid. Microspheric form shows triserial character strongly and is theoretically like the Cretaceous *Neobulimina*—a *Bulimina* become biserial. The heavy ornament, wide aperture and type of growth are unlike *Virgulina*; perhaps nearest *Sagrina*, but this is much more compressed with extensive slit aperture and vertical linear sculpture.

*Virgulopsis pustulata* n.sp. (Plate 27, figs. 72–74, 104–106.)

Initial triserial part and lower three-quarters obscured by heavy surface sculpture of irregular elongate pustules and fine papillae, about 6 biserial chambers visible (last 2 much smoother), convex with deep sutures, sides faintly convex, thickness little less than width, aperture at angle of 45°, elongate, oval, widely open, slightly rimmed. Size, 0.37 mm.

Type from 5273; restricted to Lower Awamoan and Upper Hutchinsonian; in latter seen so far only from Takaka (5056) and Waiheke Island (5041). A related form with stronger triserial part has been observed in the Burdigalian of Le Coquillat.

*Buliminella sauria* n.sp. (Plate 27, figs. 87, 97, 98.)

Quite close to the American Cretaceous *carseyi* Plummer, as figured by Cushman and Parker, 1936 (*CCL*, 12, 1, p. 8, pl. 2, fig. 6); spire lower but acute, chambers bulging near spiral suture, giving an irregularly humped appearance. The 4 chambers per whorl are often reduced to 3 in last coil. Size, 0.26 mm.

Type from 5664; index of Piripauan.

*Buliminella browni* n.sp. (Plate 27, figs. 85, 86.)

Small, globose, with blunt apex and 4 chambers to a coil, sutures faint, chambers not inflated, aperture characteristic, an elongate linear slit, parallel to and just inside base of last chamber, with rest of face appearing like a very thick surrounding lip. Size, 0.34 mm.

Type from 5540; index of Lower Bortonian.

*ELONGBULA* n.gen. (Fam. Buliminidae).

Genotype: *E. chattonensis* n.sp.

Intermediate between *Buliminella* and *Buliminoides*, more elongate, but with much lower chambers than *Buliminella*, the loosely wound spiral but little embracing, apertural face not pyriform but suboval and subterminal, small in area, central aperture chink with few radiations—this is like *Buliminoides*, but no heavy ornament or true uniserial character.

*Buliminella westraliensis* Parr, 1938 (*Journ. Roy. Soc. W.A.*, vol. 24, p. 80, pl. 2, figs. 3, 4) from the West Australian Upper Eocene belongs here, having the characteristic twisting, irregular chambers and aperture; other Australian species occur in the Janjukian of Table Cape.

***Elongobula creta* n.sp.** (Plate 27, figs. 88-91.)

Subcylindrical, about 4 loosely and irregularly wound coils, with 3-5 chambers of varying size, appearance very uneven and distorted; any part may suddenly become more swollen; apex very blunt; sutures faint, last chamber reduced, narrowing to small apertural face set almost in plane of length, with tiny central opening in a hollow. Size, 0.55 mm.

Type from 5665, abundant; index of Upper Piripauan; also present in Poverty Bay mid-Rakauroa (3250A), and Motunau Chalk Marl (5716) above sulphur sands.

***Elongobula chattonensis* n.sp.** (Plate 27, figs. 92-96.)

Like *creta* in irregular loose twist, with bulges in odd places, but much more elongate, strongly compressed in upper half, which narrows suddenly to sharply spined apex; sutures even less marked and surface smoother, size and junctions of chambers extremely irregular, last chamber hardly contracted, apertural face a sudden oblique truncation with a larger more central opening than *creta*. Size, 0.52 mm.

Type from 5368, Chatton S.D. (55 chs. S.E. of Trig. F); Duntroonian. A close relative is *Elongobula lawsi* n.sp. from 5636 (Te Kauri Stream, near Hauturu, shell-marls of basal Te Kuiti above coal outcrop); this differs only in larger size and pronounced taper (being acicular instead of subcylindrical), absence of compression, and but little twisting. They seem to be northern and southern representatives in beds of the same age.

***Ehrenbergina marwicki* n.sp.** (Plate 28, figs. 112-118.)

Very close to *mestayeri* Cushman, 1922 (see Cushman, 1927, *Proc. U.S. Nat. Mus.*, vol. 70, art. 16, p. 4, pl. 1, fig. 9), but differing in less ridged ventral surface; in Recent species a sharp angle runs from each spine along chamber, in Miocene form chambers are almost flat and terminal face distinctly convex; aperture larger, spines weaker. Size, 1 mm.

Type from 5273; Lower Hutchinsonian to Awamoan. *Mestayeri* occurs down to Opoitian (2058, etc.); another poorly preserved distinct form is in Jedburgh Taranakian.

***Ehrenbergina osbornei* n.sp.** (Plate 28, figs. 120, 123, 124.)

Wider than *marwicki*, with terminal face but little convex; ventral side with subobsolete medial ridge, smoothed away each side instead of excavate; chambers obscure and flatly convex; dorsally overlapping at third instead of quarter of width; spines few, distant, but strong spikes instead of minute points. Size, 0.6 mm.

Type from G.S. 1342; not present below Tutamoe. Also in Mokau (5197), Cheviot Grey Marl (5557), and Lower Poha (3079) (Tongaporutuan).



FIGS. 1, 2.—*Spiroplectammina steinekei* n.sp. (2, young).  $\times 30$ . FIGS. 3, 4, 6.—*Spiroplectammina piripaua* n.sp. (4, type; 6, young).  $\times 30$ . FIG. 5.—*Haeuslerella parri* n.sp.  $\times 30$ . FIGS. 7, 8, 13.—*Vulvulina jablonskii* n.sp. (7, 8, micro type; 13, megalos).  $\times 15$ . FIGS. 9, 10.—*Vulvulina duningi* n.sp.  $\times 30$ . FIGS. 11, 12, 20.—*Haeuslerella hectori* n.sp. (12, type).  $\times 30$ . FIGS. 14, 16.—*Siphotestularia acutangula* n.sp.  $\times 30$ . FIG. 15.—*Bigenerina pliocenica* n.sp. Paratype.  $\times 30$ . FIGS. 17-19.—*Plectina quennelli* n.sp. (18, type).  $\times 30$ .







FIGS. 21-23.—*Matanzia simulans* n.sp. (21, megalo type; 22, micro; 23, cross section).  $\times 30$ . FIGS. 24, 25.—*Eggerella decepta* n.sp. (24, type).  $\times 30$ . FIGS. 26-28.—*Dorotheia bifurcata* n.sp. (26, megalo; 27, micro type; 28, micro type).  $\times 30$ . FIGS. 29-31.—*Gaudryina whangata* n.sp. (29, micro type; 30, megalo; 31, megalo).  $\times 30$ . FIGS. 32, 33.—*Gaudryina reliqua* n.sp. (32, type).  $\times 30$ . FIGS. 34, 35.—*Gaudryina healyi* n.sp. (34, type).  $\times 30$ . FIGS. 36, 37.—*Pseudogaudryina anachrons* n.sp. (36, type).  $\times 15$ . FIGS. 38-40.—*Migros medwayensis* (Farr). Walkura Stream.  $\times 30$ .





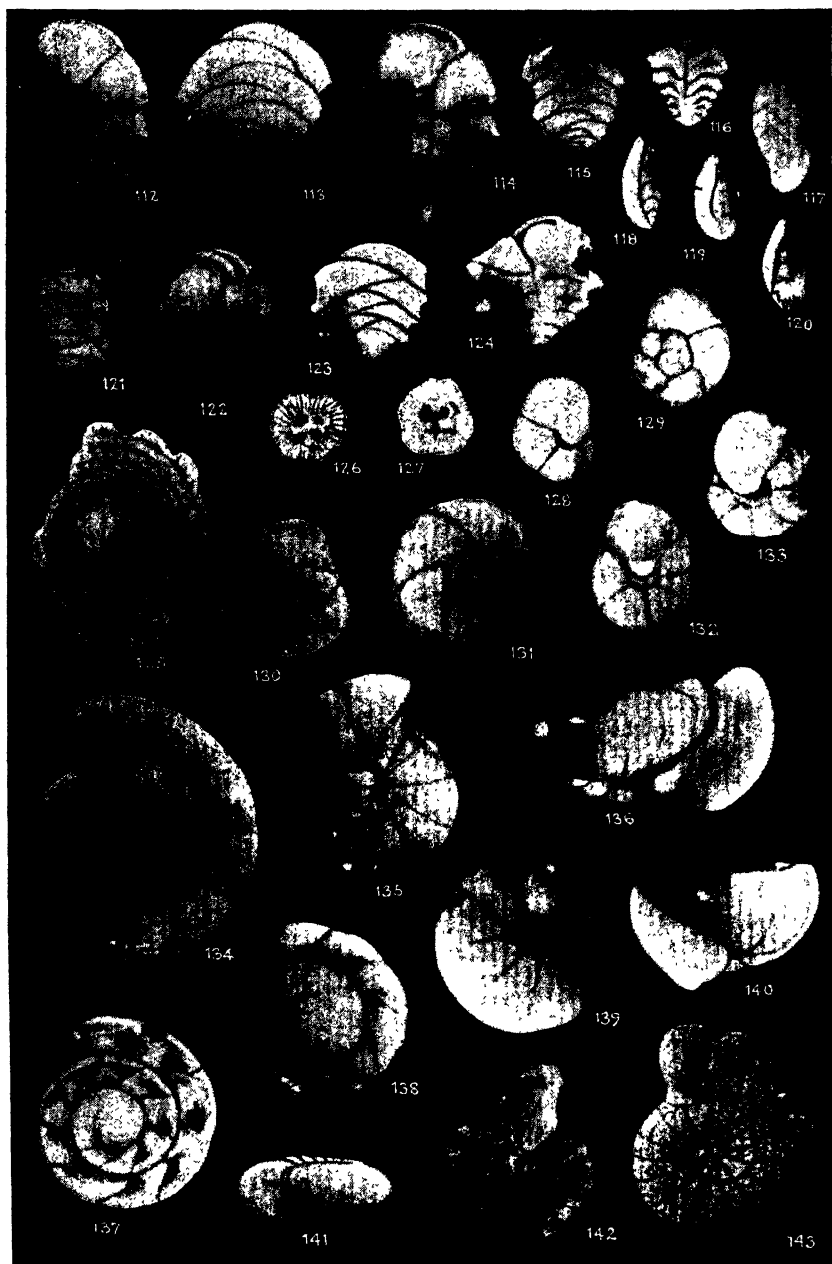
FIGS. 45, 46.—*Marginulinopsis waiparaensis* n.sp. (45, type).  $\times 30$ . FIGS. 47, 48.—*Marginulinopsis marshalli* n.sp. (48, type).  $\times 30$ . FIGS. 49, 50.—*Marginulinopsis hochstetteri* (Stache). Hampden.  $\times 15$ . FIGS. 51, 52.—*Palmula rakauroana* n.sp. (51, type,  $\times 15$ ; 52, young,  $\times 30$ ). FIGS. 53, 54.—*Palmula thalmanni* n.sp. (54, type,  $\times 30$ ). FIGS. 55, 56.—*Marginulina allani* n.sp. (56, type).  $\times 15$ . FIG. 57.—*Palmula rugosa* (d'Orb.). Poverty Bay.  $\times 30$ . FIG. 58.—*Frondicularia mucronata* (Reuss). Poverty Bay.  $\times 30$ . FIG. 59.—*Palmula birvium* n.sp.  $\times 15$ . FIGS. 60, 61.—*Frondicularia teuria* n.sp. (60, young; 61, type).  $\times 30$ . FIG. 62.—*Frondicularia steinekei* n.sp.  $\times 30$ . FIGS. 63-65.—*Planularia xhangata* n.sp. (63, type).





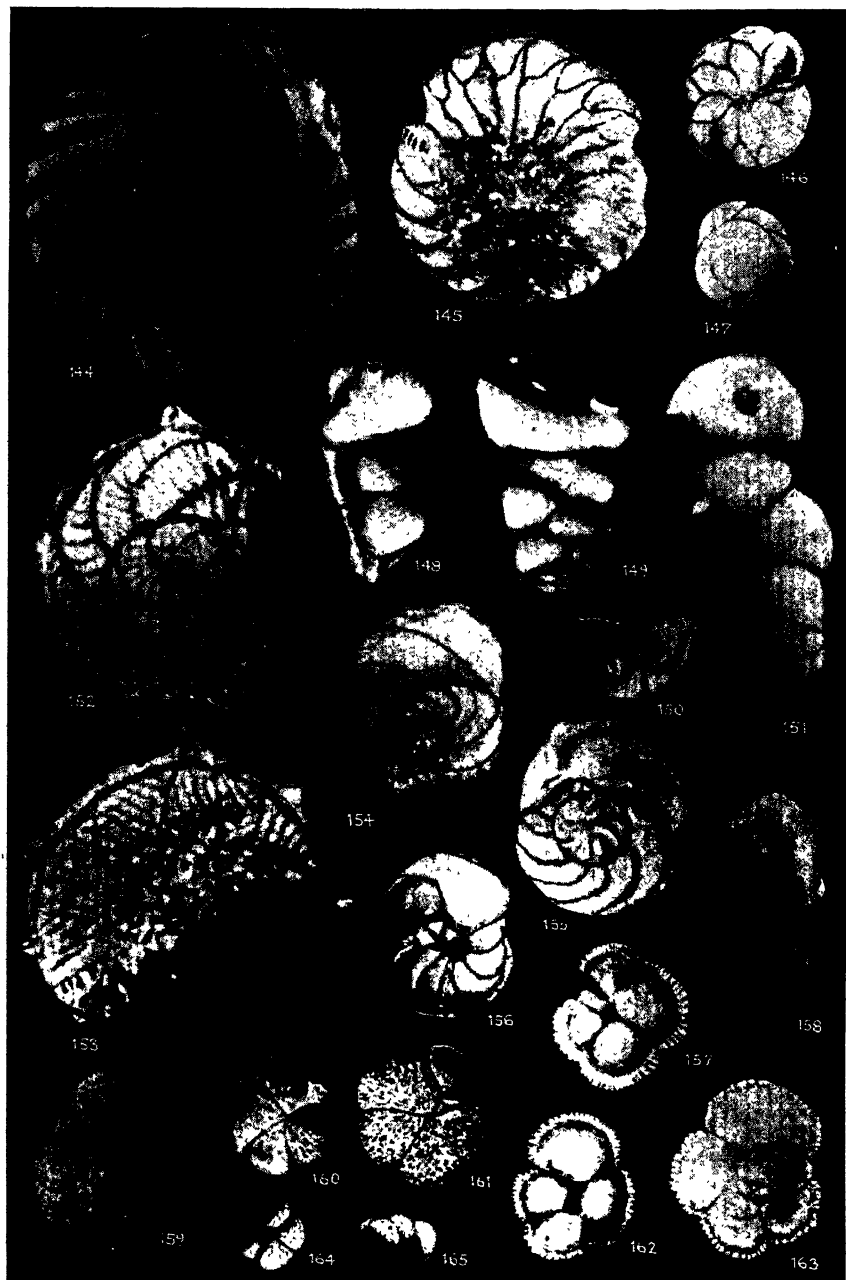
FIGS. 68, 69.—*Aragonia zelandica* n.gen. n.sp. (68, type).  $\times 45$ . FIGS. 70, 71.—*Zeaurigera parri* n.sp. (71, type).  $\times 45$ . FIGS. 72-74.—*Virgulopsis pustulata* n.gen. n.sp. (72, type).  $\times 45$ . FIGS. 75-77.—*Bolivina anastomosa* n.sp. (75, type; 77, side view).  $\times 45$ . FIGS. 78-81.—*Rectobolivina maoriella* n.sp. (78, side view; 80, type).  $\times 45$ . FIGS. 82-84.—*Rectobolivina maoria* n.sp. (83, type; 84, side view).  $\times 45$ . FIGS. 85, 86.—*Bulminella browni* n.sp. (86, type).  $\times 45$ . FIGS. 87, 97, 98.—*Bulminella sauria* n.sp. (98, type).  $\times 45$ . FIGS. 88-91.—*Elongobula creta* n.gen. n.sp. (88, type).  $\times 45$ . FIGS. 92-96.—*Elongobula chattonensis* n.gen. n.sp. (93, type).  $\times 45$ . FIGS. 99, 100.—*Bolivina pohana* n.sp. (100, type).  $\times 30$ . FIGS. 101, 102.—*Bolivina compressa* n.sp. (101, micro type; 102, megal).  $\times 30$ . FIGS. 103, 111.—*Bolivina anastomosa* n.sp. (Pakaurangi Point).  $\times 120$ . FIGS. 104-106.—*Virgulopsis pustulata* n.gen. n.sp. (104, Onekora; 105, 106, Ardgowan).  $\times 90$ . FIGS. 107, 108.—*Robulus dorotheae* n.sp. (107, type).  $\times 30$ . FIG. 109.—*Plectofrondicularia avamoana* Finlay (type).  $\times 30$ . FIG. 110.—*Plectofrondicularia tyfei* n.sp.  $\times 60$ .





FIGS. 112-118.—*Ehrenbergina marwicki* n.sp. (112, type; 117, 118, side views).  $\times 30$ . FIGS. 119, 121, 122.—*Ehrenbergina fyfei* n.sp. (122, type).  $\times 30$ . FIGS. 120, 123, 124.—*Ehrenbergina osbornei* n.sp. (124, type).  $\times 30$ . FIGS. 125-127.—*Patellina piripaua* n.sp. (125, type; others young).  $\times 30$ . FIGS. 128, 129.—*Quadrimorphina allomorphinoides* (Reuss). (Mangaotero S.D.).  $\times 30$ . FIGS. 130-133.—*Rotamorphina cushmani* n.gen. n.sp. (133, type).  $\times 30$ . FIGS. 134-136.—*Gyroidina allani* n.sp. (136, type).  $\times 30$ . FIG. 137.—*Gyroidina acrobiculata* n.sp.  $\times 30$ . FIGS. 138-140.—*Gyroidina selandica* n.sp. (140, type).  $\times 30$ . FIGS. 141-143.—*Anomalina piripaua* n.sp. (143, type).  $\times 30$ .





FIGS. 144, 145.—*Asterigerina watareka* n.sp. (144, type).  $\times 30$ . FIGS. 146, 147.—*Asterigerina lornensis* n.sp. (146, type).  $\times 30$ . FIGS. 148-151, 158.—*Vagocibicides maoria* n.gen. n.sp. (150, young; 151, type).  $\times 30$ . FIGS. 152, 153.—*Notorotalia serrata* n.sp. (152, type).  $\times 30$ . FIGS. 154-156.—*Planulina rakauoana* n.sp. (154, type).  $\times 30$ . FIGS. 157, 162, 163.—*Globorotalia crater* Finlay (Afid-Waipara).  $\times 30$ . FIGS. 159-161.—*Globorotalia mizea* n.sp. (159, type).  $\times 30$ . FIGS. 164, 165.—*Globorotalia collactea* n.sp. (164, type).  $\times 45$ .



**Ehrenbergina fyfei** n.sp. (Plate 28, figs. 119, 121, 122.)

Dorsal surface very convex, ventral flat, no medial ridge; last 2 chambers more than half ventral surface, inflated, anterior outline very convex, spines few, tiny, downward pointing. Size, 0.7 mm.

Type from 5569, Conway River, Hundalee, grey marl; Tongaporutuan. Also in 3114, Poverty Bay (Waimata, Upper Poha).

**Patellina piripaua** n.sp. (Plate 28, figs. 125–127.)

A high, rounded central cone spreading out laterally to thin disc in adults, base flat or little concave, with wide marginal ring finely divided into chamberlets and a central space with 2–4 aperture impressions dorsally smooth, opaque, disc showing several chambered rings. Size, 1.1 mm.

Type from 5329, East Grey Stream; also 5664, Mid-Waipara. Index of Piripauan. Like Parr and Collins, I cannot separate British specimens of the Recent *corrugata* Wm. from New Zealand examples—Pliocene of Castlecliff (5215) and also the Oligocene Ototaran (5182, etc.), where it is common.

**Notorotalia serrata** n.sp. (Plate 29, figs. 152, 153.)

Close to *spinosa* Chapman, 1926 (see Finlay, 1939, *Trans. Roy. Soc. N.Z.*, vol. 68, p. 517), more compressed, with subequal dorsal and ventral convexity, more numerous strong spines with spreading bases, giving a serrate appearance; *spinosa* has only a few very irregular tiny needle-shaped spikes not lobating periphery. Size, 1.4 mm.

Type from 5650, East Grey Stream, marls 90 ft. above Weka Pass Stone; also in *Pachymagas* beds, All Day Bay. Index of Lower Hutchinsonian.

*N. spinosa* is common in true Hutchinsonian and Awamoan; another Hutchinsonian form may be separated as **Notorotalia powelli** n.sp., differing in unspined hardly lobate angled periphery, very slight convexity above or below, and especially in having 12–14 chambers as against 9–10; size, 0.8 mm.

Type from Oneroa, Waiheke Island (5041), dominant there; also at Pakaurangi Point and Takaka.

**Gyroidina allani** n.sp. (Plate 28, figs. 134–136.)

Shell large for lineage, compressed, dorsally about 3 coils visible, about 11 chambers in last; sutures progressively more marked by grooves, medial area faintly convex; peripheral angle bluntly rounded, ventrally with wide umbilicus overhung by rim of little sharp plates projecting back from blunt bases of chambers. Size, 1.3 mm.

Type from 5655. Index of Duntroonian-Waitakian (very abundant). The common Miocene form of this lineage is **Gyroidina zelandica** n.sp. (plate 28, figs. 138–140) (type from G.S. 1240, Island Creek, Ihungian), which is smaller than *allani*, flat above, conic below, with similar smoothed appearance dorsally, smaller umbilicus with angular rim of chamber bases and 8 chambers per coil (never more than 9); size, 0.9 mm. Whaingaroan and probably Kaiatan forms seem inseparable, and the species appears to reach Opoiti. The

Mahoenui form is identical, but the common Taranakian species is small, with much more open umbilicus (due to its greater width and the much smaller basal pads) with a rim of less knobbed chamber ends; it may be named *Gyroidina stineari* n.sp., the type being from 5638, Tongaporutu beds of Whangamomona region; it begins with the Mokau and reaches Waitotaran. A similar non-compressed form from the Eocene is *Gyroidina scrobiculata* n.sp. (plate 28, fig. 137) (type from 5068, Burnside Marl, Tahuian); like *zelandica* in all respects except for strong dorsal excavation of chambers and coil separation, both continued far back; known only from Tahuian and Upper Bortonian. All these forms are evidently less related to *soldani* (rare here) than to *altiformis* R. E. and K. C. Stewart, but that Californian species has an open umbilicus with weak pads, and more chambers, quite differently hollowed on top. A quite different lineage, not so easily divisible into stratigraphic species, is that of *G. neosoldani* Brotzen and its allies, which is even more common throughout the Tertiary.

***Asterigerina waiareka* n.sp.** (Plate 29, figs. 144, 145.)

Large, disc-like, very compressed; dorsal surface obscure, but at least 3 coils with 22–24 chambers, sutures oblique to spiral at 45°, straight; ventrally with sinuous complicated sutures, points of chambers recurved near outer edge. Size, 1.7 mm.

Type from 5064, Lorne; common here and in basal Kaiata beds, rare in higher part of Lower Ototaran. Index of Kaiatan, especially basal part. Somewhat like *choctawensis* C. and McG., 1938 (*U.S.G.S. Prof. Paper 189D*, p. 111, pl. 28, fig. 2), of Alabama Oligocene, but much larger, more compressed, with more chambers and coils.

***Asterigerina lornensis* n.sp.** (Plate 29, figs. 146, 147.)

Much smaller and thicker than *waiareka*, with few chambers, subequally biconvex, surface obscure, about 2 dorsal coils with about 7 chambers, sutures very oblique, lightly convex; ventral pattern of chambers star-shaped, about 7 broad arms, the points almost at periphery. Surface somewhat undulating, irrespective of chambers. Size, 0.7 mm.

Type from 5064, Lorne. Not seen elsewhere.

FAMILY CHILOSTOMELLIDAE.

Cushman (*Manual*, p. 258) has noted the development of multi-chambered forms such as *Pullenia* from the biserial *Chilostomella* and has included a subfamily Allomorphinidae for triserial trochoid types. In the Cretaceous commonly occur shells extremely similar in general habit to *Allomorphina*, but with 4 or more chambers per whorl; these have so far been referred to *Valvulineria*. Such forms as *allomorphinoides*, however, seem to have developed normally from *Allomorphina* and have only isomorphic relationship with the typical Californian Miocene *Valvulineria*. Both types can occur together in the Cretaceous (see Cushman, 1931; *Tennessee Depart. Educ. Geol. Bull.* 41, pl. 9—where *umbilicatula* d'Orb. seems a true *Valvulineria*, while the aperture and habit of *allomorphinoides* corresponds far more with *Bulimina* (?) *trochoides* on pl. 7). Numerous American Tertiary species agree with Cushman's original diagnosis of *Valvulineria*,

which has a Gyroidine aperture and pad-like umbilical flap, while the other group has a more Discorbine opening with a thin free Chilostomelline lip. It seems that evolution proceeded not only in an embracing *Pullenia*-direction, but also in a rotaloid one from *Allomorphina* to *Quadrимorphina* and finally to *Rotamorphina*.

**QUADRIMORPHINA** n.gen. (Fam. Chilostomellidae).

Genotype: *Valvulina allomorphinoides* Reuss, 1880 (Austrian Miocene) (as figured and described by Cushman, 1931; *l.c.*, p. 53, pl. 9, figs. 6 a-c. from the American Navarro).

Test flatly trochoid, with 4 chambers to a coil, otherwise exactly like *Allomorphina* Reuss.

The genotype occurs commonly in New Zealand in the Eocene and rarely in the Upper Cretaceous (Piripauan) (e.g., 5301; pl. 28, figs. 128, 129), where the transition from *Chilostomella* through several species of *Allomorphina* to this and finally the following genus is rather easily followed. The species of *Allomorphina* figured by Cushman, 1936 (*CCL*, 12, 4, pl. 13) are all represented here by allied or identical forms. The species *trochoides* (Reuss) has oscillated between *Valvulina*, *Allomorphina* and *eggerella*, but its aperture and development are unlike the latter genus and entirely relate it to *Allomorphina*; it is common here in Cretaceous and Eocene.

**ROTAMORPHINA** n.gen. (Fam. Chilostomellidae.)

Genotype: *Rotamorphina cushmani* n.sp.

Test depressed rotaloid, with more than 4 chambers in a coil (6-7 in type species); development and type of aperture as in *Quadrимorphina*.

**Rotamorphina cushmani** n.sp. (Plate 28, figs. 130-133.)

1932. *Valvulinaria allomorphinoides* Cush., *Proc. U.S. Nat. Mus.*, vol. 80, p. 46, pl. 14, figs. 2 a-c, non Reuss.

Calcareous, smooth, thin-walled, with flat evolute dorsal surface, rounded periphery and deeply umbilicate base; 6-7 chambers per coil, sutures distinct, narrow; umbilicus overhung by thin plate-like continuation of last chamber, masking entirely ventral aperture. Size, 0.7 mm.

Type from 5301. Index of Piripauan, common in Whangai. The Trinidad Upper Cretaceous form figured by Cushman seems almost certainly the same, and is a further link between our Whangai and this fauna. The Mexican Oligocene *Globorotalia palmarealis* Nuttall, 1932 (*Journ. Pal.*, vol. 6, pt. 1, p. 30, pl. 7, figs. 1-3) at first sight looks very similar, but seems to belong to a different line derived from *Discorbis*; it is probably congeneric with what Brady has figured as *saulcii* d'Orb. (*Chall. Rep.*, vol. 9, pl. 41, fig. 6). Both these forms are represented in our Hutchinsonian; they are strongly perforate, while *Rotamorphina* has the smooth texture and shell structure of the Chilostomellidae.

**Anomalina piripaua** n.sp. (Plate 28, figs. 141-143.)

One and a-half dorsal coils with 12-13 chambers; sutures lightly curved, not limbate, faint; whole surface strongly punctate with fine wrinkling round peripheral area, umbilicus serrated by chamber ends. Periphery very bluntly sub-angled; the linear aperture extending over whole of its contact with last chamber. Size, 1 mm.

Type from 5664. Index form of Piripauan; found also at many Hawke's Bay and Poverty Bay localities; superficially resembling *Nonion*, which has not yet been found in our Cretaceous.

**Planulina rakauroana** n.sp. (Plate 29, figs. 154–156.)

Sub-discoidal, dorsally lightly convex with about 3 coils; about 8 chambers in each, very elongate and curved, swollen medially, sutures not limbate, faint, spiralling far backwards. Ventrally more convex, with narrow deep umbilicus overhung by little flaps from ends of swollen chambers, sutures deep, very rounded. Aperture not clear, mostly ventral, but sometimes also round periphery. Size, 1 mm.

Type from 5664. Index form of Piripauan, especially lower. More involute base than *taylorensis* (Carsey), much more curved dorsal sutures.

**Genus VAGOCIBICIDES** n.gen. (Fam. Cibicididae).

Genotype: *V. maoria* n.sp. (Miocene, N.Z.).

Attached by flattish or concave dorsal surface, a few early chambers coiled as *Cibicides*, then several biserial chambers, which become staggered and finally uniserial; ventral surface very convex, chambers usually subglobular; aperture even in coiled stage in centre of terminal face, with slight raised rim, not connected with periphery or dorsal surface; in later stage migrating still further from periphery (even approaching previous ventral suture) and set in a crater-like depression. Walls thick, smooth, shining and of subporcellaneous appearance; perforations so extremely fine and dense that still invisible under magnification of 36.

**Vagocibicides maoria** n.sp. (Plate 29, figs. 148–151, 158.)

The generic details also stand for the species. Shape quite variable, mostly tends towards subcylindrical elongation, occasionally spreading; a translucent rim marks periphery; sutures conspicuous, at first flush, later narrowly sunken. Size, 1.4 mm.

Type from 5651, East Grey River, marls 100 ft. above Weka Pass Stone. Lower Hutchinsonian to Opoitian, and one Recent occurrence (50 f., off Otago Heads).

At first sight very like *Stichocibicides cubensis* Cush. and Berm., 1936 (CCL, 12, 2, p. 33, pl. 5, figs. 19–21) in its smooth appearance, but differs generically in biserial character and aperture. Nearest to *Dyocibicides* Cush. and Val., which has a larger coiled part much less absorbed in shell, a different apertural position, and is coarsely perforate. The smooth glossiness of *Vagocibicides* is its most apparent feature.

**Globorotalia miozea** n.sp. (Plate 29, figs. 159–161.)

Of the *hirsuta* d'Orb. type, variable in shape and thickness, both *menardii* and *tumida* forms occurring in all gradations; dorsally usually lightly convex, last chambers more flattened, about 2 coils with usually 5 chambers; sutures very convex; periphery increasingly lobulate with age, but not cordate; ventrally subconical at angle of about 140°, chamber bases narrowly swollen but not pointed, sometimes depressed; sutures deep, sinuous; no umbilicus, aperture sometimes narrow, usually fairly open with slight lip along outer side;

whole shell densely perforate; dorsally smooth; ventrally with dense tiny pustules clustering around lower part of chambers, decreasing in size with subsequent chambers, last 2 smooth; periphery sharp-angled to quite rounded. Size, 0.8 mm.

Type from 5089, Eason's Hill, Greymouth "Blue Bottom." Rare in Lower Hutchinsonian, abundant after that and reaching Waitotaran. For comparison are figured (plate 29, figs. 157, 162, 163) specimens of *G. crater* Finlay (*Trans. Roy. Soc. N.Z.*, vol. 69, pt. 1, p. 125) from the lowest Bortonian of mid-Waipara (5671). Another Bortonian species is *Globorotalia collectea* n.sp. (plate 29, figs. 164, 165), which differs from the Miocene *scitula* and allied forms in non-globular chambers, flattened at top and sides, covered with minute papillae, instead of punctate; open aperture and umbilicus; 5 chambers per coil (4 in young); size, 0.23 mm. (Type from 5540, but more common in Upper Bortonian.)

EXPLANATION OF LOCALITY NUMBERS REFERRED TO MORE THAN ONCE.  
G.S. 1342. Poverty Bay, Patutahi S.D., Waikura Stream, basal Tutamoe.

3249. Poverty Bay, Waipiro S.D., top of Lower Rakauroa.

3250A. Poverty Bay, Waipiro S.D., Tuparoa Stream, mid-Rakauroa cherts.

3270. Poverty Bay, Mangaoporo S.D., basal Rakauroa.

5064. North Otago, Lorne, type of Waiarekan tuffs; basal Kaiatan.

5273. North Otago, All Day Bay, Awamoan blue clays.

5301. Dannevirke area, Mangaotero S.D., 125 chs. at 59° from Trig. U.

5329. North Canterbury, East Grey Stream, black clays above sulphur sands.

5338. Dannevirke area, Mangaotero S.D., 175 chs. at 74° from Trig. U.

5374. Dannevirke area, Mangaotero S.D., 148 chs. at 61° from Trig. U.

5540. North Otago, Hampden Beach section, 22 chs. at 162° from Trig. H.

5655. North Otago, Otiake, shell bed above limestone.

5664. North Canterbury, Mid-Waipara, top of Saurian beds.

5665. North Canterbury, Mid-Waipara, base of Waipara greensands.

#### LIST OF NEW NAMES PROPOSED.

##### GENERIC.

*Migros* n.gen. (Fam. Verneuilinidae). Genotype: *Gaudryina medwayensis* Parr. (Middle Miocene-Recent.)

*Aragonia* n.gen. (Fam. Heterohelcidae). Genotype: *A. zelandica* n.sp. (Upper Cretaceous-Eocene.)

*Virgulopsis* n.gen. (Fam. Buliminidae). Genotype: *V. pustulata* n.sp. (Lower and Middle Miocene.)

*Elongobula* n.gen. (Fam. Buliminidae). Genotype: *E. chattonensis* n.sp. (Upper Cretaceous-Upper Oligocene.)

*Quadriformina* n.gen. (Fam. Chilostomellidae). Genotype: *Valvulina allomorphinoides* Reuss (Upper Cretaceous-Eocene.)

*Rotamorphina* n.gen. (Fam. Chilostomellidae). Genotype: *R. cushmani* n.sp. (Upper Cretaceous, Campanian?).

*Vagocibicides* n.gen. (Fam. Cibicididae). Genotype: *V. maoria* n.sp. (Lower Miocene-Recent.)

## SPECIFIC.

- Spiroplectammina steinekei* n.sp. (Santonian-Campanian).  
*Spiroplectammina piripaua* n.sp. (Santonian-Campanian).  
*Vulvulina jablonskii* n.sp. (Middle Miocene).  
*Vulvulina büningi* n.sp. (Campanian).  
*Siphotextularia acutangula* n.sp. (Upper Mid-Eocene).  
*Siphotextularia wangamua* n.sp. (Uppermost Pliocene).  
*Hauserella hectori* n.sp. (Lower Miocene).  
*Hauserella parri* n.sp. (Lower to Middle Pliocene).  
*Bigennerina pliocenica* n.sp. (Lower Pliocene).  
*Gaudryina whangaia* n.sp. (Campanian).  
*Gaudryina healyi* n.sp. (Santonian).  
*Gaudryina reliqua* n.sp. (Lowest Mid-Eocene, perhaps Lower Eocene).  
*Pseudogaudryina anachrons* n.sp. (Upper Oligocene).  
*Eggerella decepta* n.sp. (Lowest Mid-Eocene, perhaps Lower Eocene).  
*Dorothia biformis* n.sp. (Santonian-Campanian?).  
*Dorothia agrestis* n.sp. (Lower Mid-Eocene).  
*Plectina quennelli* n.sp. (Upper Mid-Eocene).  
*Plectina agrestior* n.sp. (Upper Mid-Eocene).  
*Matanzia simulans* n.sp. (Campanian).  
*Matanzia mahoenuia* n.sp. (Lower Miocene).  
*Robulus dorothiae* n.sp. (Lower Miocene).  
*Palmula rakauaroana* n.sp. (Santonian).  
*Palmula thalmanii* n.sp. (Campanian).  
*Palmula bivium* n.sp. (Upper Mid-Eocene).  
*Palmula bensoni* n.sp. (Upper Eocene).  
*Palmula taranakia* n.sp. (Middle Oligocene-Lower Miocene).  
*Fronicularia teuria* n.sp. (Campanian).  
*Fronicularia steinekei* n.sp. (Santonian).  
*Planularia whangaia* n.sp. (Campanian).  
*Planularia rakauaroana* n.sp. (Santonian-Campanian).  
*Marginulinopsis marshalli* n.sp. (Lower Mid-Eocene).  
*Marginulinopsis waiparaensis* n.sp. (Lowest Mid-Eocene, perhaps Lower Eocene).  
*Marginula allani* n.sp. (Upper Oligocene).  
*Sigmoidella bortonica* n.sp. (Lower Mid-Eocene).  
*Aragonia zelandica* n.sp. (Upper Mid-Eocene).  
*Bolivinita pohana* n.sp. (Upper Miocene-Middle Pliocene).  
*Bolivinita compressa* n.sp. (Upper Miocene).  
*Bolivinita pliozea* n.sp. (Lower to Upper Pliocene).  
*Plectofronicularia fyfei* n.sp. (Upper Miocene).  
*Zeauwigerina parri* n.sp. (Mid-Eocene).  
*Bolivina anastomosa* n.sp. (Lower Oligocene-Middle Miocene).  
*Bolivina pontis* n.sp. (Lowest Oligocene).  
*Bolivina affiliata* n.sp. (Middle Miocene-Middle Pliocene).  
*Rectobolivina maoria* n.sp. (Lower Miocene to Lowest Pliocene).

- Rectobolivina maoriella* n.sp. (Lower to Middle Miocene, perhaps Upper).  
*Virgulopsis pustulata* n.sp. (Middle Miocene).  
*Buliminella sauria* n.sp. (Santonian).  
*Buliminella browni* n.sp. (Lower Mid-Eocene).  
*Elongobula creta* n.sp. (Campanian).  
*Elongobula chattonensis* n.sp. (Upper Oligocene).  
*Elongobula lawsi* n.sp. (Upper Oligocene).  
*Ehrenbergina marwicki* n.sp. (Lower to Middle Miocene).  
*Ehrenbergina osbornei* n.sp. (Middle to Upper Miocene).  
*Ehrenbergina fyfei* n.sp. (Upper Miocene).  
*Patellina piripaua* n.sp. (Santonian).  
*Notorotalia serrata* n.sp. (Lower Miocene).  
*Notorotalia powelli* n.sp. (Lower Miocene).  
*Gyroidina zelandica* n.sp. (Lower Oligocene-Lowest Pliocene).  
*Gyroidina stineari* n.sp. (Upper Miocene-Lower Pliocene).  
*Gyroidina scrobiculata* n.sp. (Middle to Upper Eocene).  
*Asterigerina waiareka* n.sp. (Lower Oligocene).  
*Asterigerina lornensis* n.sp. (Lowest Oligocene).  
*Rotamorphina cushmani* n.sp. (Campanian).  
*Anomalina piripaua* n.sp. (Santonian-Campanian).  
*Planulina rakauaroana* n.sp. (Santonian-Campanian).  
*Vagocibicides maoria* n.sp. (Lower Miocene-Lower Pliocene & Recent).  
*Globorotalia miozea* n.sp. (Lower Miocene to Lower Pliocene).  
*Globorotalia collectea* n.sp. (Middle Eocene).

## Additions to New Zealand *Rhyacophilidae*—Part 1.

By A. G. MCFARLANE, M.A.

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### HISTORICAL.

RHYACOPHILIDAE from New Zealand have been described by R. McLachlan (1866, 1870), R. J. Tillyard (1924) and E. J. Hare (1909). Hare's species, *Hydrobiosis ingenua*, will never be recognisable, as it was inadequately described and never figured. The type has since been destroyed.\* Omitting Hare's species, there are at present eleven species of Rhyacophilidae recorded from New Zealand. Of these, *Hydrobiosella stenocera* Till. belongs to the Philopotamidae, and *Neurochorema decussatum* Till. is a synonym for *Psilochorema confusum* McL., leaving nine valid species. Part 1 of this paper adds eight species, thus bringing the number to seventeen. The matter is of interest as the further additions proposed for Part 2 will, for the time being, easily displace the Sericostomatidae as the dominant family for New Zealand, as regards numbers of species and genera.

### GENERAL.

The synonymy noted above, *Psilochorema confusum* McL. = *Neurochorema decussatum* Till., requires further attention. It is not thought advisable at present to sink the genus *Neurochorema* Till., as it could well serve to receive *Ps. confusum* McL., which is certainly not congeneric with the genotype, *Ps. mimicum* McL.

The species here described and those in Part 2, with one exception, are the results of collecting confined, in the main, to the upper Waimakariri River watershed. All, with the exception noted, were obtained by rearing mature pupae in aquaria, during the course of a study of life-histories. Adults of this family are not readily taken in the field.

The figures in this paper, with the exception of those of *Costachorema brachyptera*, are from slide preparations. The Comstock-Needham notation, as modified by Tillyard (1924) has been used for neurulation.

I would like to acknowledge with thanks the advice and assistance given me by Mr. M. E. Mosely, of the British Museum, and by Professor E. Percival, of Canterbury University College.

### KEY TO THE NEW ZEALAND GENERA OF RHYACOPHILIDAE.

(Modified after Tillyard).

1. Forewing with branches of M normally developed. . . 2  
     Forewing with  $M_2$  and  $M_3$  fused basally for some  
     distance, so that an apparent apical fork is formed  
     between them. . . . . *Neurochorema* Till. ♂ ♂
2. Forewing with radial cell open. . . . . 8

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\* Letter from Mr. M. E. Mosely, January, 1937.

- Forewing with radial cell present, closed by a cross vein; not symmetrically pointed at apex. . . . . 3
3. Radial cell not followed distad by a second small closed cell. . . . . 4
- Radial cell of forewing followed distad by a second small cell enclosing the wing spot. . . . . 7
4. Forewing with both  $Af_1$  and  $Af_2$  sessile on radial cell. 5
- Forewing with either  $Af_1$  or  $Af_2$  or both stalked from the radial cell. . . . . 6
5. Apex of forewing short; forks 1 and 4 absent in hindwing with Sc about half wing length; Sc in forewing running alongside or fused with  $R_1$ . . . *Hydrochorema* Till.
- Apex of forewing long; forks 1, 2, 3 and 5 present in hindwing; Sc and  $R_1$  ending close together in hindwing. . . . . *Percivalia* n.g.
6. Forewing with  $Af_1$  sessile on radial cell,  $Af_2$  stalked. *Hydrobiosis* McL.
- Forewing with  $Af_1$  stalked,  $Af_2$  sessile on radial cell. *Neurochorema* Till. ♀ ♀
7. The small cell distad from the radial cell in forewing is closed distally by the fusion of  $R_4$  and  $R_5$ ; veins of distal part of forewing neither close together nor parallel. . . . . *Synochorema* Till.
- The small cell distad from the radial cell is closed distally by a cross-vein; veins in the distal part close together and parallel. . . . . *Psilochorema* McL.
8. Forewing with apex symmetrically pointed; inferior appendages of ♂ one-jointed. . . . . *Tiphobiosis* Till.
- Forewing not symmetrical at apex; widest at tornus; inferior appendages of ♂ two-jointed. . . . . *Costachorema* n.g.
- Note: *Hydrobiosella* Till. has been omitted from Tillyard's key as it belongs to the Philopotamidae.

#### Genus PERCIVALIA nov.

Differing from *Hydrobiosis* McL. in neururation of forewings, in the form of the genital armature and aedeagus, in the abdominal organs of the male, and in having relatively longer and more robust limbs.

Maxillary palpi long and clothed fairly densely with short hair; two basal joints short, together shorter than the third joint which is longest; labial palpi shorter than first three joints of maxillary palpi; mentum bifid, making labial palpi appear four-jointed; ocelli present, small; antennae fine, a little shorter than forewings; wings similar in sexes; forewings narrow, apex acute, pterostigma variably defined, venation normal, forks 1 and 2 in forewing sessile on radial cell, which is short; hindwing with radial cell open and  $Af_4$  absent; aedeagus complex, without flum; inferior appendages one-jointed; organs on fifth abdominal sternite of shield type in the female; in the male, pouches between the second and third segments dorsally.

The genus resembles *Hydrochorema* Till. in neururation, but differs in genitalia, in abdominal organs, and in larvae.

Genotype: *P. maxima* n.sp.

This genus is dedicated to Professor E. Percival, of Canterbury University College.

*Percivalia maxima* n.sp. Figures 1, 5, 7, 9, 10.

Expanse: ♂ 33 mm. ♀ 33 mm.

A large insect of golden-brown appearance. Head dark brown clothed on vertex and frons with a shaggy mass of stout, long hairs ranging in different specimens from light golden-brown to blackish-

brown; eyes black, ocelli ranging from white to yellow; antennae fine, basal joint short and stout, as long as the second and third together, yellowish-brown, ringed with bands of fine dark hair, becoming lighter towards the tips; palpi a little finer than the antennae, finely pubescent.

Thorax: prothorax narrow, carrying a dense clothing similar to that on the head; mesothorax having a deep median hollow anteriorly, the lateral ridges with hair like that on the prothorax; tegulae densely covered with similar hair; metathorax lighter in colour, bare; legs pale golden brown, 2, 4, 4, long and strong, fore-legs shorter with darker tarsi; forewings thickly clothed with intermixed light and dark brownish hairs, with strong yellowish to golden-brown upstanding hairs along the veins, particularly in the basal portion; veins yellowish, distinct; fringe, varying shades of brown; hind-wing hyaline, smoky towards the apex, long light hairs on veins in the anal region.

Abdomen in male: sparse hair on lower and posterior edges of tergites, except eighth tergite where the hair-bearing region is two crescentic areas with an incised hairless region between them; posterior margin of seventh sternite with blunt, peg-like tooth; of the eighth with a broad backward extension. The ninth sternite is curved in such a way that the anterior edge is posterior to the posterior edge of the sternite, and from the side appears as a backwardly directed tooth. The posterior margin of the ninth tergite is broken mid-dorsally by a circular excision extending to the anterior margin. From the bay so formed the protiger rises. Superior appendages, like long, narrow hair brushes rise from the sides of the excision, close to the dorsal margin of the sternite, and bear stout spines on the dorsal surface. Outside these are two lobes with fine hair, and immediately below them are the long twisted intermediate appendages, much longer than other appendages. The inferior appendages are rooted deep in the pit enclosing the genitalia, and curve out and back from their point of origin, their inner surfaces concave, thickly covered with fine hair and shallowly granular in texture; aedeagus dark brown, complicated; the penis curves upward between a pair of claw-like, downward-directed penis guides; parameres slender, dilated towards the point, which is clawed.

In the female the shield on the fifth sternite ends in a wedge-shaped tooth, less than half as long as the succeeding sternite; sixth sternite bears a shorter and blunter tooth; seventh, or ultimate visible sternite, with rounded posterior margin, notched mid-ventrally.

Holotype ♂, allotype ♀, and series paratypes in Canterbury Museum.

Habitat: small stony streams in beech forest between 1000 and 3000 ft.

*Percivalia fusca* n.sp. Figures 6, 11, 12.

Expanse: 22 to 25 mm.

Smaller and darker than *P. maxima*.

Head less hairy than *P. maxima*; vertex hairs black with lighter hairs intermixed; lighter hairs predominating on the frons; oculi

black with light lines and flecks, these probably being post-mortem effects; ocelli small, light; maxillary palpi covered on upper and outer surfaces with dense, fine, fuscous hair; labial palpi with fine light hair; antennae shorter than forewing, fine, dark, clothed in fine blackish hair to the tips.

Thorax less hairy than *P. maxima*, mesothorax having light hair on the two ridges; legs light yellowish brown in proximal parts, first and second pairs brownish black with bands of yellowish on tibiae and tarsi, third pair light yellowish-brown as far as tarsi, which are lighter than other pairs.

Wings: forewing pterostigma well defined; venation yellowish, strongly defined; surface of wing, with dense fuscous hairs, longer than in *P. maxima*. From the distal end of the pterostigma, a light crescentic band crosses the wing; several light spots basad from this, marking patches of light hair rising from the veins, which are clad mainly with upstanding fuscous hair; light spots on the margin between the termini of the veins; fringe dense, varying from light to fuscous; hind-wing hyaline, dark smoky effect distally; fringes in anal region, long, light and silky.

Abdomen: female, tooth on fifth sternite as long as succeeding sternite and slightly curved; tooth on sixth short, and blunt; seventh or ultimate visible sternite longer than preceding ones, notched posteriorly; the eighth tergite appears to have no corresponding sternite. Male: long tooth on seventh sternite; eighth sternite short with broadly rounded backward extension, ventrally, of the posterior margin; posterior margin of ninth sternite produced to a point mid-ventrally. Dorsally, the posterior margin of the ninth tergite is excised by a shallow bight about two-thirds of its width, and from this the proctiger rises. From the sides of this excision the club-like superior appendages point downwards and inwards; their ends are pointed and dorsal surface studded with short blunt spines; between the superior and intermediate appendages lies a low wart-like ridge; intermediate appendages, rounded, longer than others; the inferior appendages rise from a cavity and are directed postero-dorsally; they curve in towards the mid-line so that the inner surfaces come to face ventrally at the distal end. Aedeagus, dark brown; penis bifid at point, directed upwards between a pair of hooked guides, which partly surround it near the point; a pair of stout pointed rods rise dorsal to the penis; conspicuous dark brown, rod-like parameres curve from the base, outwards and downwards, and turn up at the points.

Holotype ♂ and allotype ♀ and series of paratypes in Canterbury Museum. Preparations of wings and genitalia in Museum.

Habitat: small rapid streams in beech forest between 2000 and 3000 ft.

*Percivalia cassicola* n.sp. Figures 2, 13, 14, 15.

Expanse 25½ mm.

This insect is very like *P. fusca* superficially, but is more robust, more uniformly coloured, light spots on wings as in *P. fusca* being absent, and with denser wing covering.

Head: antenna not so dark as in *P. fusca*, becoming lighter towards the tips; covering and colour of head, palpi and thorax much the same as *P. fusca*.

Forewings densely and evenly covered with fine fuscous hair. Veins with upstanding coarse black hair, interspersed with a few lighter hairs; light spots at both ends of pterostigma, which is well defined; a few white hairs about M<sub>4</sub>, opposite the distal end of the pterostigma; a further patch about the hyaline area at the point of bifurcation of Cu<sub>1</sub>; no light crescentic band as in *P. fusca*; fringes short, very small light spots between the termini of veins.

Female adult unknown, but a nymph, which is almost certainly of this species, shows the posterior edge of the terminal sternite as entire, as contrasted with the notched margin of *P. fusca*; other adult features shown by the nymph did not vary greatly from *fusca*.

Abdomen in male with a short tooth on the antepenultimate sternite; penultimate tergite very narrow mid-dorsally; ultimate tergite reduced to a stout wire-like ridge, from below which the proctiger rises; ultimate sternite more than twice as long latero-ventrally as it is mid-ventrally; appendages subequal in length; the superior appendages curve downward from a stout base to flatten to a spatulate form in the horizontal plane, and lie between the intermediate and inferior appendages; intermediate appendages long and subcylindrical; the inferior appendages, viewed from the side, are straight; viewed from below they are seen to taper from a broad base and to have an angular projection on the inner side near the base; aedeagus of the kind figured for the genotype; parameres dark, rod-like, each with an outwardly directed tyne near the point.

Holotype ♂ and two paratypes ♂ in Canterbury Museum. Wings and genitalia mounted.

Habitat as for *P. fusca*.

**Percivalia banksiensis** n.sp. Figures 16, 17.

Expanse 24 mm.

This insect is uniformly light golden-brown throughout and conforms closely with the genotype.

Abdomen ♂ short tooth on antepenultimate sternite; penultimate sternite with broadly rounded mid-ventral extension; ultimate sternite drawn out on posterior margin to a blunt peg-like process, thin and almost transparent; viewed laterally the three terminal sternites appear to be toothed; ultimate tergite reduced to a strong ring of chitin, convex posteriorly; posterior margin of penultimate tergite with two tufts of hair widely separated; the under side of the proctiger has a backward-pointing, V-shaped, sclerotised band; superior appendages club-shaped from above, dorso-ventrally flattened; inferior appendages broad basally, tapering sharply on the inner side to turn abruptly inwards at the tip; aedeagus of usual type for genus; large brown parameres, somewhat like a red deer's antler, tip turned sharply outward, two outwardly directed tyne at third distance from tip and base respectively, the basal one much the larger; viewed from below the parameres make a double crossing near the tip.

Holotype, unique ♂ Canterbury Museum Collection; abdomen in balsam.

Taken by A. L. Tonnoir at Hilltop, Banks Peninsula, January, 1925. I have taken what appears to be the larvae of this species in a stream on the Peninsula.

Genus *COSTACHOREMA* nov.

Head broad; eyes large; a large bare groove between eyes and lateral ocelli; maxillary palpi long, the terminal joint the longest; labial palpi very small.

Forewings narrow, acute, fore and hind margins almost straight; neuration dissimilar in sexes; in the male the costal margin folded back dorsally as far as  $R_1$  or less widely, and Sc., which is short, returns to  $R_1$  instead of to C.; in the female the costal fold is absent and Sc. returns to C. normally; venation otherwise similar; forks one to five present; radial and median cells open. Hindwings similar in sexes; fourth cell absent; fairly broad, with fore and hind margins roughly parallel.

Abdomen of female large, with weakly defined shields on fifth sternite; terminal part laterally compressed; male with eversible organs dorsally between second and third segments; genitalia conspicuous; inferior appendages two-jointed; aedeagus complicated, with two or three pairs of appendages distally; no tergite, dorsal to ultimate sternite.

Genotype: *Costachorema psaroptera* n.sp.

This genus is erected to contain four species of medium to large-sized insects, one of which, *C. brachyptera* n.sp., exhibits abnormal wing development. I have a female of what appears to be a fifth species. It resembles *C. xanthoptera* n.sp. in general appearance, but has rounded wing tips, and is lighter in colour. Expanse 16 mm., which is very much smaller than any other species of the genus.

***Costachorema psaroptera* n.sp.** Figures 4, 8, 18, 19, 20.

Expanse: male, 30 mm.; female, 30 to 35 mm.

Head: antennae shorter than forewings, basal joint large, inner surface with fine white hair, outer side bare; remainder light yellowish-brown, annulations being indistinct basally, and increasingly fuscous distally; sparse black hairs on occipital ridge; two lines of white hair from the median ocellus backwards; a dense covering on frons of mixed coarse black and white hair; eyes large, dark; ocelli light; maxillary palpi dark, finely pubescent.

Thorax: prothorax narrow, a few long white and black hairs upstanding; mesothorax long, deep chestnut, two lines of long, fine, white hairs anteriorly; metathorax bare, brown; legs, long; hind-legs pale yellowish-brown; middle and forelegs darker on tibiae and tarsi, but yellowish-brown proximally.

Forewings in male folded at anterior margin as far as  $R_1$ , fold extending from the base to the pterostigma, which is small, and covering the greater part of Sc. and the humeral veinlet. This fold is opaque and is double; in the male Sc. meets  $R_1$  a little basad from the fork of  $Rs$ ., and in the female opposite the point of bifurcation

of  $R_4$  and  $5$ ; termen slightly concave; fringe short with light spots at termini of veins; wing semi-transparent, finely mottled greyish effects in the distal half, faintly brownish in the proximal half; a thin white band from the distal end of the pterostigma to  $Cu_2$ , roughly parallels the apical margin; a band of black hair from the base of the wing parallel to the posterior margin as far as the junction of  $A_2$  and  $A_3$ ; from the end of this in the male, to a little beyond the end of  $A_3$ , is a white patch with a tuft of white hair, on  $Cu_2$ , while in the female this area is light brown with a narrow hyaline line from the terminus of  $A_3$  to the point of bifurcation of  $Cu_1$ ; veins strongly marked, concolorous with the mottling of the wing, and with sparse, weak, light to white, upstanding hairs; the wing membrane is clothed sparsely with fine hairs, white and darker, and, in the region of the tornus, with occasional reddish hairs; hind wings hyaline with light fringes.

Abdomen dark above and light yellowish-brown below; in the female no tooth on the fifth sternite, a small one on the sixth, and a larger broad tooth on the seventh; part posterior to the seventh segment laterally compressed and no sternites visible; in the male the antepenultimate sternite is toothed; in the penultimate segment the tergite is twice as long as the sternite and wider; posterior margin of terminal tergite is broadly incised, and, from the angle of the incision, is a deep mid-dorsal cleft; the superior appendages are semi-transparent, brown; seen from the side each appears as two very prickly leaves; from below each is like a letter U on a short stalk, the inner side of the U being densely covered with stout brown spines (fig. 20); the chitinous base of the appendages extends on the under side of the proctiger to form a fish-tail; two thin chitinous plates sheathe the distal part of the proctiger ventrally; intermediate appendages fine and clubbed; short hairy appendages at their bases, dorsally; inferior appendages strong, concave on inner surfaces of both joints, with strong spines on the inner edges of the basal joints. The aedeagus is a soft, bulbous organ, the terminal portion of which can be rotated through  $180^\circ$  in the dorso-ventral plane; when fully extended the small pair of terminal appendages take up the middle position; the parameres are bifid from the base, the longer outer portion having a tuft of brown bristles towards the end.

Holotype  $\sigma$ ; allotype  $\varphi$  and series of paratypes; and preparations of wings and genitalia in the Canterbury Museum.

Habitat: fast, stony, cold streams in open tussock country from 1000 to 2600 ft. above sea level. Plentiful in suitable streams.

**Costachorema xanthoptera** n.sp. Figs. 21, 22.

Expanse: 25 to 30 mm. in  $\sigma$ ; 36 to 40 mm. in  $\varphi$ .

There is a marked disparity in the expanse of the males and females in my collection. A similar disparity exists in the bodies of the sexes, particularly in the abdomens.

Head: hairs on vertex, light yellowish-brown, with a few brown hairs; antennae fuscous, finely and sparsely pilose; palpi as for genus, a little darker than antennae, basal segment of antenna bare on outer surface; eyes large, dark.

Prothorax small, with hair as on head; mesothorax brown, with scanty hair like that on prothorax; metathorax light brown, bare; legs long and entirely light tawny, except for brown claws.

Forewings: light tawny, semi-transparent, clothed very sparsely with light yellowish to brownish hair; a few darker upstanding hairs on the veins in the anal region; a strong fuscous fringe on the basal part of the costa; light hairs in the fringe opposite the termini of veins; pterostigma small and faintly marked in ♂, large and well marked in the ♀; costal margin in ♂ folded narrowly as far as pterostigma, with subcosta meeting  $R_{1+2}$  a short distance basad from the point of forking of the radial sector, but the point of union is variable. Hindwings: hyaline, faintly tawny, fringes light.

Abdomen reddish brown above, lighter below; ♀ with terminal segment laterally compressed; shield on fifth sternite ill-defined; no ventral teeth, but a small tubercle on the penultimate sternite; posterior margin of ultimate sternite extended midventrally to a broad, blunt point. In the type male, the organs between second and third tergites are everted; a short peg-like tooth on the penultimate sternite; genitalia conspicuous; superior appendages large, bright brown, curving back and up above the proctiger. There is a line of strong spines, beginning near the base, ventrally, and curving to the outside to become dorsal distally. These, together with the dense fringe of hair from the eighth tergite, conceal the genitalia from above in a fresh specimen; the proctiger is long and narrow with two plates ventrally, projecting laterally near the end; intermediate appendages slender, clubbed, with wart dorsally at base; inferior appendages long in basal joint, which is deeply concave on the inner surface; terminal joint short, carried folded inwards; aedeagus brown, strongly chitinized, three pairs of long sharply-hooked terminal appendages; parameres long, rod-like.

Holotype ♂, allotype ♀, and paratypes in the Canterbury Museum.

Habitat: open country gravelly streams, of non-shifting substratum, cold waters; larvae from Glentui (North Canterbury), Kowai River, at east foot of Porter's Pass, and fairly numerous about Mount White bridge, Cass. An adult from the Waimakariri, a tributary of the Waikato, North Island (Prof. Percival).

These insects appear to complete their period of emergence by the end of December. Pre-pupae are again to be found in May.

**Costachorema callistum** n.sp. Figs. 23, 24.

This insect resembles *C. psaroptera* in general proportions, but is readily distinguishable by its warmer wing colouring, with a reddish tinge along the posterior margin of the forewing, by the lesser contrast between colour of body and hairy covering, and by the distinct annulations of the antennae, which are visible to the naked eye.

Expanse: 24 mm. ♂.

Head brown, vertex clothed with black hairs interspersed with yellow; frons covered less densely than *C. psaroptera*, with short yellow and black hairs; max. palpi grey, finely pubescent; labial palpi lighter, short; antennae strongly ringed, fuscous and yellowish-brown; eyes large, dark; ocelli white.

Prothorax inconspicuous, with long upstanding hairs similar to those on tegulae and mesothorax; legs yellowish-brown proximally, posterior pair with darker bands on tarsi; middle and forelegs strongly banded yellow and dark fuscous on tibiae and tarsi; spurs 2, 4, 4, anterior very small. Wings as for genus, outline like *C. psaroptera*; but termen not concave. Sc. returns to R.<sub>1</sub> opposite point of bifurcation of Rs.; fold in costal margin, narrow, not covering Sc.; dense black fringe proximally on costal margin; wing membrane clothed more densely and with longer hair than in *C. psaroptera*; white hair of latter replaced by golden; a tuft of black upstanding hair on A.<sub>2</sub> between its points of contact with A.<sub>3</sub> and A.<sub>1</sub>; in the cubital region, particularly distally, wine red hair forms the greater part of the wing covering; hindwings hyaline with fuscous fringes.

Abdomen light reddish-brown above, pale yellowish-brown below; hair, dorsally, fine, light, sparse; on terminal tergite, long, golden; no ventral teeth; penultimate sternite much shorter mid-ventrally than laterally; ultimate sternite extending laterally above the plural region; the eighth segment is produced dorsally to a blunt projection; from beneath the sides of this a pair of lightly chitinated triangular plates project; the proctiger is stout and hides from view the superior app. and aedeagus; sup. app. brown, spoon-shaped, the concave surface of the spoon opening downwards, the convex surface fitting into a depression in the soft proctiger; just posterior to the supp. app., a pair of triangular flaps project from the ventral surface of the proctiger; intermed. app. curved and enlarged distally, directed upwards; inf. app. broad in the basal joint, short and dark brown in the terminal joint; both joints concave on the inner surface; aedeagus brown, strongly chitinated, with three appendages terminally, two of which are hooked to point downwards; a long paramere with a slender stem and a broad flat terminal portion is bent up to lie lateral, and adjacent to the sup. app.

Holotype: unique male; in Canterbury Museum; abdomen in balsam. The larva of this species is known to me. The adult probably emerges in the autumn, judging from the condition of larvae collected in mid-summer.

Habitat: Broken River and Cragieburn River, above West Coast road, and Mount Baldy, Cass, at 2600 ft. Cold, stony streams, unstable sub-stratum.

**Costachorema brachyptera** n.sp. Figs. 3, 25, 26, 27.

A very robust insect, almost black in colour when fresh. Wing abnormality appears to be the rule. Only three females out of a collection of a score of this species are winged genotypically as to shape and size. Expanses of six females were 23, 25, 28, 33, 34, and 35 mm. Ten males were 19, 19, 20, 21, 22, 23, 23, 25, 28 and 29 mm. There is not a corresponding disparity in body sizes within each sex. Wings of short-winged females do not reach the end of the abdomen, but are sub-equal in males. The insects, though flightless, are active runners. This species is the largest in the genus.

Head almost black; eyes black; ocelli light, hair on vertex confined to occipital ridge and two small warts; a tuft above the median

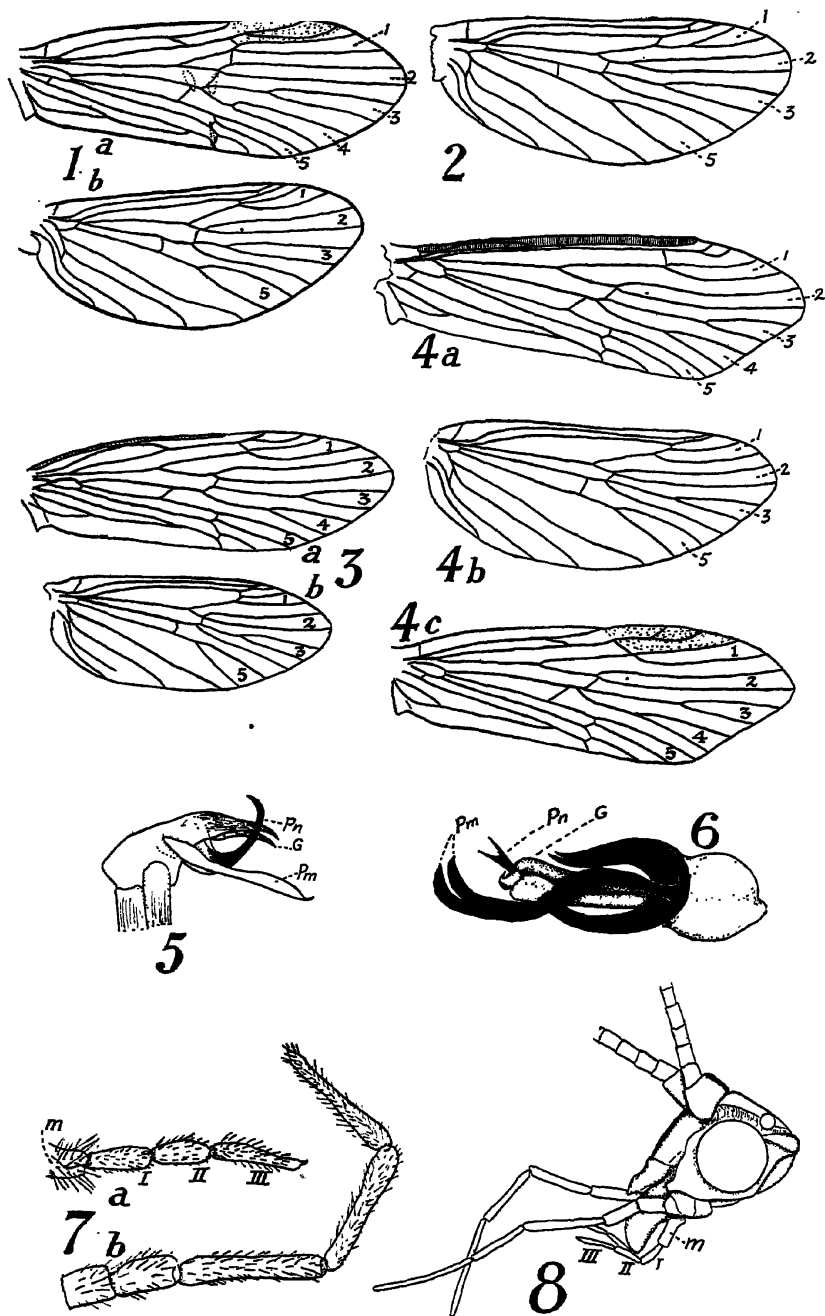


FIG. 1.—*Percivalia maxima* n.sp. wings ♂. FIG. 2.—*Percivalia cassicola* n.sp. hind wing ♂. FIG. 3.—*Costachorema brachyptera* n.sp. wings ♂. FIG. 4.—*Costachorema psaroptera* n.sp. wings (a), (b) ♂, (c) ♀. FIG. 5.—*Percivalia maxima* n.sp. aedeagus. FIG. 6.—*Percivalia fusca* n.sp. aedeagus. FIG. 7.—*Percivalia maxima* n.sp. (a) labial palpi, (b) maxillary palpi. FIG. 8.—*Costachorema psaroptera* n.sp. head of fresh specimen.



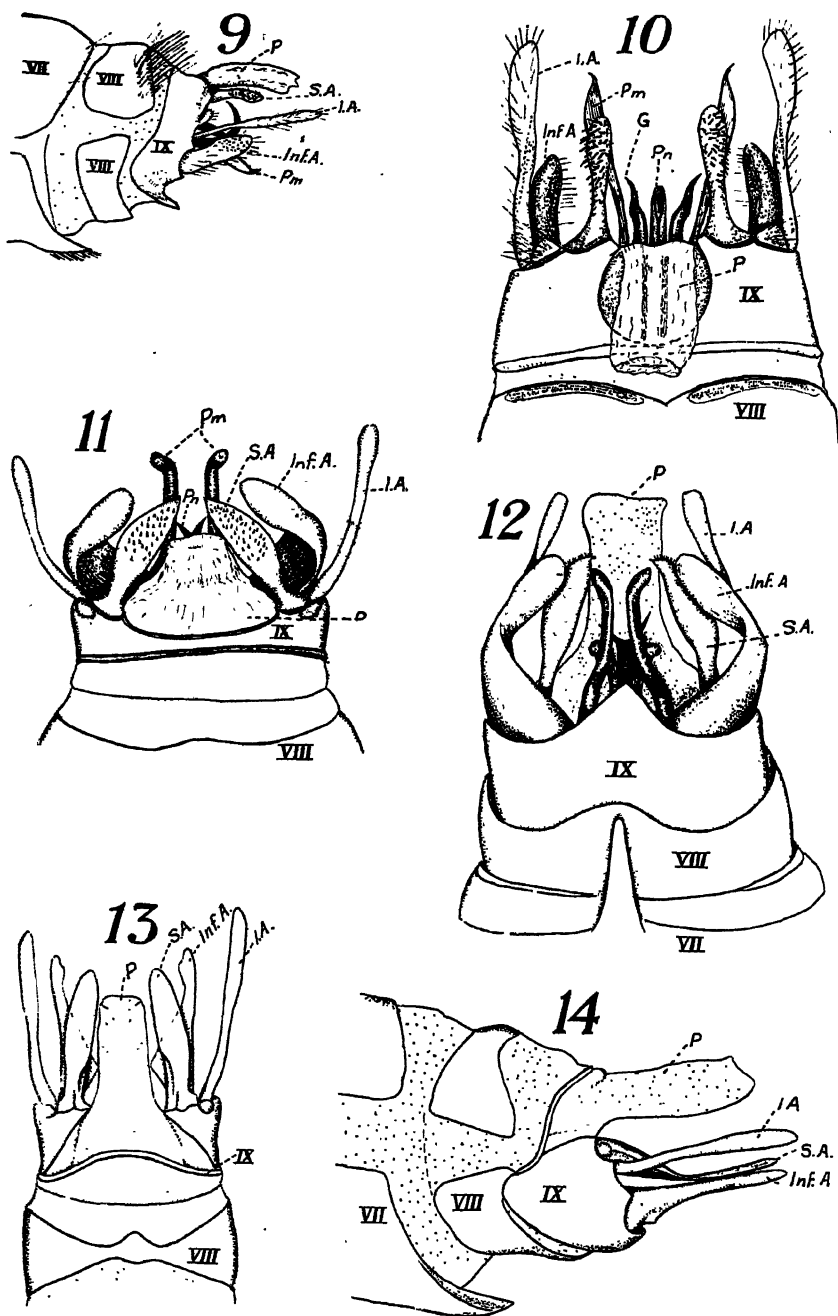


FIG. 9.—*Percivalia maxima* n.sp. lateral ♂. FIG. 10.—*P. maxima* dorsal ♀.  
 FIG. 11.—*P. fusca* n.sp. dorsal ♂. FIG. 12.—*P. fusca* n.sp. ventral ♀. FIG. 13.—  
*P. cassicola* n.sp. dorsal ♀. FIG. 14.—*P. cassicola* n.sp. lateral ♀.



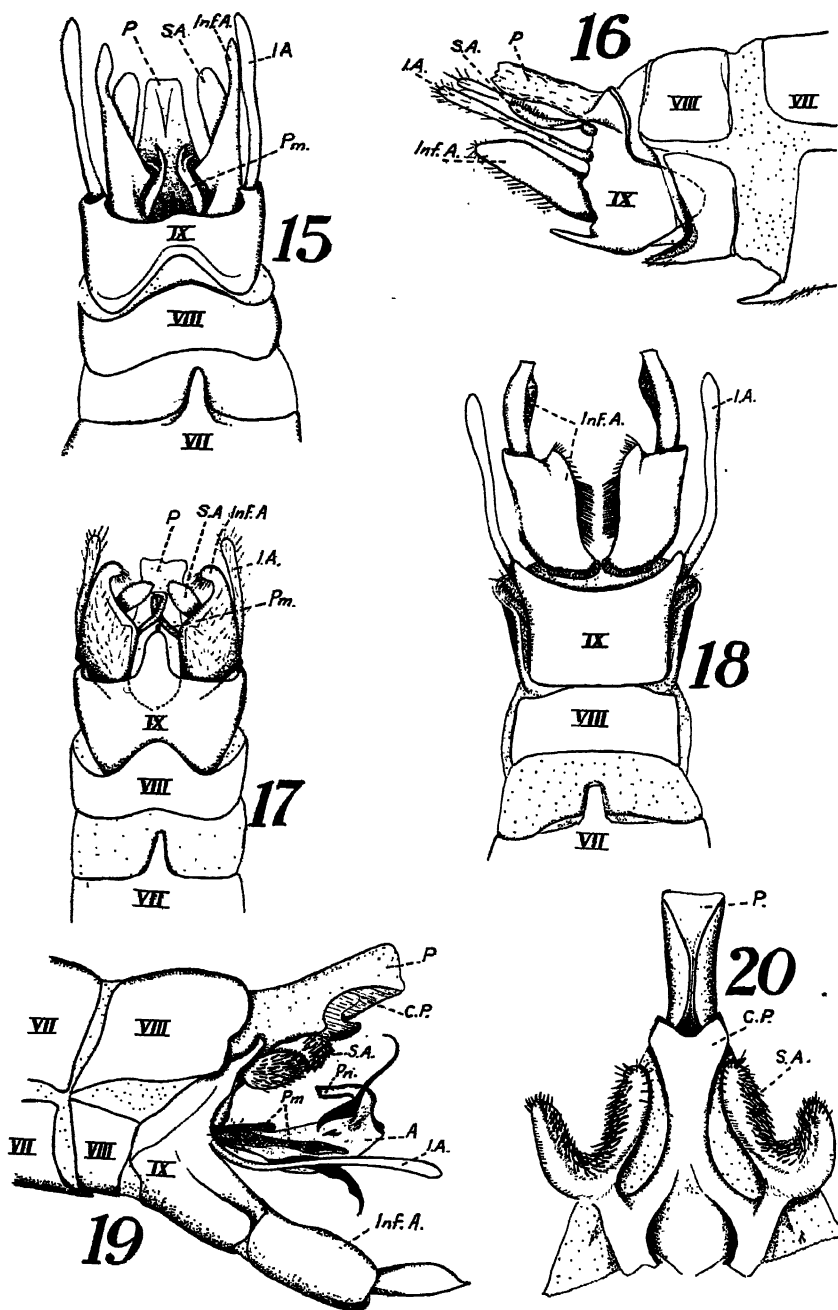


FIG. 15.—*Percivalia cassicola* n.sp. ventral ♂. FIG. 16.—*P. banksiensis* n.sp. lateral ♂. FIG. 17.—*P. banksiensis* n.sp. ventral ♂. FIG. 18.—*Costachorema psaroptera* n.sp. ventral ♂. FIG. 19.—*C. psaroptera* n.sp. lateral ♂. FIG. 20.—*C. psaroptera* n.sp. proctiger from below, showing superior appendages and sclerotised plate C.P. ♂.



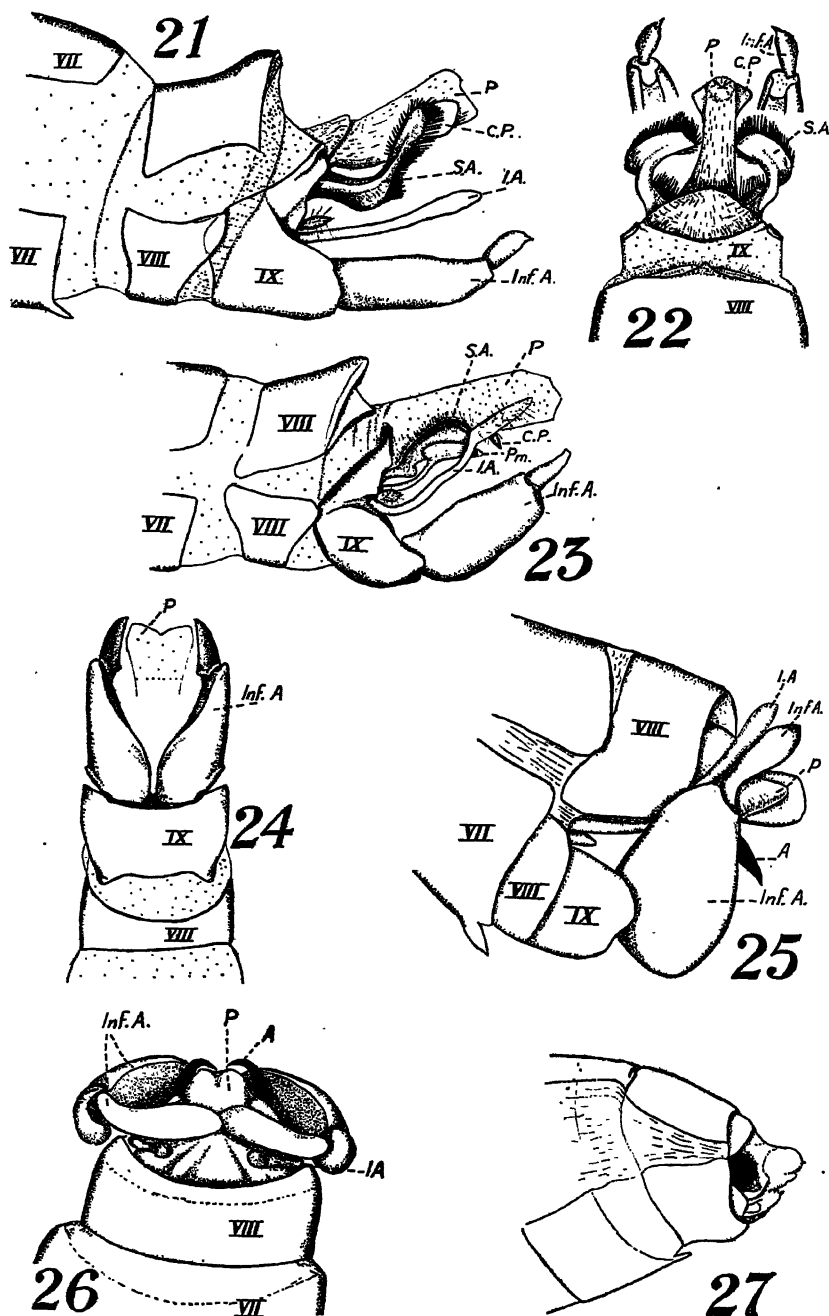


FIG. 21.—*Costachorema xanthoptera* n.sp. lateral ♂, aedeagus omitted. FIG. 22.—*C. xanthoptera* n.sp. dorsal ♂, showing tips of inferior appendages. FIG. 23.—*C. callistum* n.sp. lateral ♂, aedeagus omitted. FIG. 24.—*C. callistum* n.sp. ventral ♂, aedeagus and other appendages omitted. Tip of proctiger showing. FIG. 25.—*C. brachyptera* n.sp. lateral ♂. FIG. 26.—*C. brachyptera* n.sp. dorsal ♂, terminal hooks of aedeagus showing. FIG. 27.—*C. brachyptera* n.sp. lateral ♀, end of abdomen, dark plate cross-hatched.



ocellus and dense hair of frons black, with a few brown hairs intermixed; sides of genae wide and bare; antennae fine, longer than wings of short-winged forms, black, very finely pilose, annulated brown.

Prothorax wider than usual in this family; long hair over the tergum and plurae, black above and lighter at sides, ending just above bases of coxae in a tuft of forwardly directed golden-brown hair; mesothorax dark, glossy brown; a few brown hairs; metathorax light, bare; legs long and robust; coxae brown; anterior surfaces of fore and middle coxae clothed with long brown hair; hind legs and femurs of others, yellowish-brown; tibiae and tarsi of fore and middle legs brown.

Wings vary in form from the somewhat symmetrical type figured to a form like that of the genotype; the holotype shows patches of golden hair, and similar hair in the fringe opposite the termini of veins; the folded costal area in the ♂ is narrow; the forewings of all specimens agree in being semi-transparent, in having venation strongly marked, in being sparsely covered with hair; the fringes are short, dark, and absent from the basal part of the posterior margin; the hindwings are transparent and fairly evenly and sparsely covered with fine black hair, and the fringes short, black.

Abdomen dark brown above, lighter below; ♀ very robust; shields on fifth sternite weakly defined; sixth sternite with a short peg-like tooth, seventh or last visible sternite with posterior margin well defined, brown, and produced mid-ventrally in an obtuse angle; from beneath the margin of the seventh sternite, on each side of the process is a rounded chitinous flap, possibly parts of a much reduced eighth sternite; immediately posterior to the process is a triangular plate, cleft at the apex; laterally, from beneath the sides of the seventh segment, come two hard concave sclerites, chestnut in colour; the terminal part of the abdomen is compressed between these sclerites.

In the ♂ the abdomen is sub-cylindrical and ends abruptly, with very little taper. A short tooth on the antepenultimate sternite; ninth segment apparently incomplete dorsally; proctiger short, broad, with a lobe on each side; inferior appendages large, brown, with darker, club-like styles encircling the genital cavity to meet above the proctiger; intermed. app. small, and directed upward inside the inf. app.; genital cavity deep and large, with dark brown terminal hooks of aedeagus projecting like sister-hooks. In the genital cavity are three pairs of appendages dorsal to the intermed. app. The lowest—blade-like, dark brown, widest at the base—is probably a paramere of the aedeagus; the middle one—short, slender and clubbed—is probably the sup. app.; the upper, which is broad and short, is apparently homologous with the chitinous plates below the proctiger in the genotype (fig. 20, C.P.).

Holotype ♂, allotype ♀ and series of paratypes in Canterbury Museum. Wings and genitalia mounted.

Habitat: Edwards River, in Arthur's Pass National Park, at 3500 feet above sea-level. The stream is very cold and fast, but the substratum not greatly subject to disruption.

Adult insects February to May.

## LETTERING OF FIGURES.

A.: Aedeagus.

C.P.: Sclerotised plate beneath proctiger.

G.: Penis guides.

I.A.: Intermediate appendage.

Inf.A.: Inferior appendage.

M.: Mentum.

P.: Proctiger. An unsclerotised segment (?) carrying the anus.

Pm.: Paramere of the aedeagus.

Pn.: Penis. The terminal part of the aedeagus.

S.A.: Superior appendage.

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*Carposina adreptella*.

By F. J. JEFFREYS, M.Sc., Cawthron Institute.

[Received by Editor, December 22, 1938; issued separately, December, 1939.]

THE Carposinidae, to which *Carposina adreptella* belongs, are regarded either as a family in the super-family Tortricoidea with Tineoid affinities or as a family related to the Orneodidae and Copromorphidae. The family and also the genus *Carposina* are most strongly represented in Australia and the Hawaiian Islands, though species of *Carposina* occur in most zoogeographical regions. There are 15 species of *Carposina* in New Zealand, and the generic diagnosis is as follows:—

## Genus CARPOSINA.

Antennae in ♂ moderate or long ciliations (1.4). Palpi rather long or very long, longer in female, porrected, second joint with projecting scales above and beneath, terminal joint more or less concealed. Forewings with 8 separate. Hindwings with cubital pecten, seldom in ♂ developed into a large expansible tuft of hairs; 3 and 5 stalked, 6 absent.

*C. adreptella*, the larvae of which are destructive to the buds and fruit of raspberry and blackberry, was described by Walker (12) in 1864 as *Gelechia adreptella*. It was subsequently placed by Meyrick in the genus *Paramorpha*, then in *Heterocrossa*, and finally (7) in *Carposina*. Confirmation of the identity of the species under study was secured by comparison with a series of specimens in the Cawthron Institute collections. The male genitalia were compared with the figures and descriptions given by Philpott (10) and with his original mounted preparations.

## DESCRIPTION OF STAGES.

*Adult.*

The moth has been described by Hudson (4) and by Meyrick (6), whose description is reproduced here.

“Male, female; 14–17 mm. Head and thorax grey, more or less irrorated with whitish; palpi in male moderate in female very long, lower half dark fuscous; antennae in male whitish-ochreous. Forewings very narrow, costa moderately arched, slightly bent before middle, hindmargin straight, very oblique; greyish-ochreous or grey, sometimes mixed with whitish, especially towards base of costa, and more or less densely irrorated with blackish-grey; costa with about seven small suffused blackish-grey spots; a suffused blackish-grey spot in disc at 2/3 from base; between this and base are about eight black dots in upper half of wing, irregularly arranged, tending to be followed by raised scales; a large raised tuft on the discal spot, and another on submedian fold at 1/3 from base; an angulated transverse row of blackish dots from 3/4 of costa to anal angle; a hindmarginal row of similar dots; cilia dark grey, with whitish points. Hindwings whitish, apex sometimes greyish; cilia whitish.”

*C. adreptella* is a very variable moth, some individuals being very light in colour, others very dark, darkish-brown, or dark grey. Again some appear to be more or less uniform in colour; this is usually the case with the darker forms, while on the lighter ones darker spots are usually shown. One variety has a pair of dark converging lines (fig. 1), as mentioned by Philpott (9). The dark grey specimens are difficult to distinguish from pinned specimens of *C. iophaea*. The forewings have two conspicuous raised tufts of scales, one lying anteriorly, and a larger one posteriorly with a small tuft between the two; the hindwings are cream-coloured with long hairs posteriorly. When in natural position the left wing slightly overlaps the right, and the antennae are hidden beneath the body (fig. 2). The male can usually be distinguished from the female by the long hairs on the end of the abdomen. On the male antennae are minute hairs, which are absent in the female. The moths vary in size, usually from 6 mm. to 10 mm. in length.

The male genitalia were described by Philpott (10). The following are the characteristics of the female genitalia. On the dorsal inside surface of the ductus bursa (fig. 3b) where it opens to the exterior is a long tube-like process slightly swollen at its end and arising between two flaps. The ventral surface of the ductus bursa has a smooth plate roughly serrated at its end. The duct is dorso-ventrally flattened and has small scale-like thickenings over it. It narrows into a thinner-walled tube and opens into a thin-walled sac which has no markings. In the bursa copulatrix (fig. 3a), distending it, there is frequently found a coiled thick-walled tube, at one end of which is a thinner-walled bulb-like enlargement, the other end being twisted and broken off. This structure is probably a sperm sac left by the male after copulation. It was found in 58 females out of 112, but was not found in two females known to be virgins. It was not found in 104 males dissected, but this was probably because the males had either mated or the sac was formed by a secretion from the male or female or from both (13). In one case there were three sperm sacs in a single bursa, and in four other females two sacs were removed from each bursa. This probably indicates that the one female was mated three times and the other four twice.

#### *The Egg.*

The egg (fig. 4), which is about 0.5 mm. in length and sub-spherical, is thin-walled, with the surface raised into small, rounded areas. At the cephalic or micropyle end, three circles of forked spines arise, each spine being placed at the intersection of ridges dividing the surface at this end into triangular areas (fig. 5). At the centre there is a circle of about 5 small pits surrounded by a smooth area divided into 7, 8 or 9 different parts.

The egg is yellowish-green in colour to begin with, but changes during development to a yellowish-gold, the area under the spines becoming orange, which, as development continues, spreads till more than half the egg is coloured.

#### *The Larva.*

The first instar larva is about 1 mm. in length. The head and dorsal portion of the prothorax are dark in colour, the rest

of the body is whitish cream. The surface of the body appears to be granulated.

The number of instars has not been ascertained, but appears to be either 4 or 5. The head width of the first instar is 0.195 mm., that of the final instar varies from 0.78 to 0.89 mm.

The final instar larva is about 10 mm. in length. The under surface is yellowish-green, depending on the amount of food in the alimentary tract. The head dorsally is a light shining brown with the mouth parts giving it a reddish-brown to black colour anteriorly. The dorsal surface of the prothorax is sclerotized and pigmented. The markings and chaetotaxy can be seen from the figures 6 and 7.

The colour of the darker patches on the dorsal surface varies in different individuals. The darker parts are usually different shades of brown, a blackish to a reddish-brown, the lighter portions vary from brown through pinkish-brown to red. The general appearance is mottled with the dorsal darkness broken medially by a longitudinal light stripe. The longitudinal light band between the dorsal and lateral darker portions is emphasised by contrast with the darkest portion on the dorsal surface. The colour of the larva probably depends on the nature of its food and the position in which it has been living.

The ocelli are distinct, light in colour and arranged in a half-circle about a darker area. Their arrangement can be seen in figure 7. Between the frons and the epicranium (fig. 8) are a pair of narrow adfrontals which are separated from the epicranium by an unpigmented suture, while the strongly developed epicranial suture is very dark. A pair of pits and three pairs of setae are carried on the frons, while on each adfrontal is a very small seta, a small seta, and a pit. On each of the epicranial halves on the dorsal surface are 4 pits and 3 very small setae posteriorly, while the other 6 setae are larger, 3 being medium in size and 3 long. On the ventral surface posteriorly there is one short seta and a pit. One seta is enclosed by the half-circle of ocelli, one long seta is postero-ventral to them and one medium-sized seta is ventral; the latter has two pits, one on either side, one more ventral and the other posterior. On the antero-ventral corner is a medium seta, and a long seta lies posterior to it with a short one mid-ventral.

The antennae (fig. 9) have three joints. The basal joint carries no setae, the basal membrane is well developed. The middle joint is the longest of the three and carries on its outer side towards the distal end a very long seta with a short one slightly below and more dorsal. Over halfway down a pit is present below the long seta on the outside edge. Two cones, one more dorsal and one ventral with a small spine between the ventral cone and the long seta, are carried on the distal end of the middle segment. At the end of the terminal segment a short spine is carried ventrally with a very small spine beside it on the inner side, as well as a cone more dorsally and a seta in a socket on the outer dorsal corner.

The labrum (fig. 10) is two-lobed. On the dorsal surface there are four setae on each lobe. There are two on the outside edge, the longer being slightly more towards the tip, the other two are more

median, the one slightly nearer the base and not so near the mid-line between the lobes being the longer of the two. On the ventral surface there are two setae on each lobe towards the tip and in the middle of the lobe. On each lobe, just below the surface, are three triangular areas, each of which opens into the floor of the mouth by a median pit. Slightly in from the margin the surface is pitted. Behind the middle triangular area there is another pitted area. Towards the median line a single seta is found with much smaller setae lying in the area between the lobes. Further back these merge into more spine-like reclinate processes which cover a wider area.

Each maxilla (fig. 11) consists of a three-jointed palp and a lobe. On the under or dorsal surface of the lobe there are three short, stout setae which are in sockets. On the tip or anterior end of the lobe are two segments with a small joint on top of each of them. Between these two there is a small spine, while on the ventral surface of the tip of the lobe a couple of small spines are found, one medially and the other towards the outer edge. On the tip of the terminal joint of the palp are seven small spines. On the middle segment of the palp there is a pit on the outer edge and a seta on the basal segment on the inner ventral anterior end of the joint. The palpifer has a long seta on the anterior edge ventrally. The stipes have two long setae ventrally, one on the anterior margin of the sclerite, the other medially on the posterior margin. On the inner surface the stipes is elongated into an "L"-shaped process, one end of which reaches up just beyond the ventral end of the palpifer, the heel of the "L" pointing inwards towards the mid-line of the head, the foot of the "L" lying below the membranous base of the stipes. The cardo is small and is found posterior to this portion of the stipes.

The labium (fig. 12) consists of a spinneret and two palps, as well as a submentum and a lightly chitinised mentum which has two long setae. The palps have a comparatively long basal joint with a small terminal joint at its end. A short seta is found on the inner ventral surface of the distal end of the first segment, and a long seta arises from the end of the second. The spinneret is rounded apically with a median swelling. At the base of the spinneret are two short setae.

The mandibles (fig. 13) are stout. Each is nearly square in outline, while its basal area is triangular, the longest side forming the inner basal edge, and the other two sides the outer basal edge. The outer surface is slightly convex and carries two hairs towards the base ventrally. Up the inner surface, which is more markedly concave, there run four ridges to the four teeth of the apical edge, the two median teeth being better developed than the outer teeth.

The setal number and arrangement as compared with *Carposina fernaldana* (3) is similar in the thoracic segments, but varies slightly in the abdominal ones. The first abdominal segments are similar; the second abdominal segment of *C. adreptella* has one less seta of group vii. Among the larvae of *adreptella* itself there is a variation in the number of setae on the ventral surface of segments 3 to 6. Usually there is a group of four setae (vii) on the latero-ventral area of the segment, but in some cases only three setae are present on

one or more of the segments, often on one side only. In *fernaldana* there are three setae only, not the usual four of *adreptella*. The rest of the setae are the same in these segments. Segments seven and eight are similar in both caterpillars. In *adreptella*, on segment nine, there is an extra small seta dorsally. Segment ten is not depicted for *fernaldana*, but in *adreptella* there is a total of 13 setae, 4 dorsally, the remainder ventral, terminal or lateral. On each proleg there is a single circle of crochets; a uniordinal, uniserial arrangement.

There is no definite anal comb, but there are a number of spines developed on both the ventral and dorsal surfaces, slightly smaller and more scattered on the ventral surface.

#### *The Pupa.*

The pupa shows certain characters which are found in the Tineidae—it has many similarities with the Heliodinidae, which family, from its pupal characters, according to Mosher (8), appears to be related to the Tortricids.

The pupa is about 6 to 7 mm. in length and is at first a greenish-cream, but later it darkens, due to the development of the adult pigmentation. Ventrally the appendages nearly completely obscure the abdominal segments when these are lying in their retracted position. In the drawing of the pupa (fig. 14) the segments are expanded to show the position of the setae and are not in their more normal retracted position. In both male and female segments 4 to 7 are moveable, the last three segments (8–10) being incapable of independent movement. A ridge or crest is developed dorsally on the frons (fig. 16), the margins of which ventrally are raised into ridges continuous with the crest. The vertex is raised into ridges anteriorly and medially on either side of the epicranial suture. The pronotum is short, the mesonotum has a median ridge with a smaller ridge on either side and its caudal margin is produced into a long lobe (Heloidinidae). The metanotum is consequently lessened in the median line and is not one fourth the mesal length of the mesonotum (Hel.). Laterally the surface of the abdomen is rugose and the small sub-circular spiracles lie between the ridges. The setal arrangement can be seen in fig. 14, there being but a single row of setae in each segment. Ventrally there are no setae on the last three segments or dorsally on the last two, but the tenth segment carries on either side of its posterior end two short spines which are directed outwards.

The ventral aspect of the pupa can be seen in fig. 15. The wings come to a point terminally but do not reach as far caudally as the antennae or the metathoracic legs (which reach beyond the antennae). The mesothoracic legs do not reach the end of the wings but further than the maxillae. The prothoracic legs reach nearly three-quarters of the way down the maxillae, which are 15/17ths the length of the wings. Between the proximal portions of the maxillae the labial palps can be seen. The seven or eight terminal segments of the antennae are distinct, but further back this separation is lost and the segmentation is only shown by swellings on their ventral surface.

The appendages are closely joined together and are quite distinct but are not easily separable. They are attached to the body wall as far as the fourth segment. From the fifth segment caudally the abdomen is separated from them. A spine is carried on the ventral surface at the end of each of the metathoracic legs. On the inner surface, against the abdomen, each of the metathoracic legs carries three spines towards its outer edge, the first a little more than halfway down the free portion of the leg and the other two spaced evenly between this and the distal end. On the ventral surface of the sixth abdominal segment there is a pigmented, hardened area raised in small ridges (figs. 17 and 18), which is possibly a stridulating organ.

The anal opening is in a hollow in the centre of a raised area on the tenth segment. The male genital (fig. 17) aperture is a small slit, slightly bifurcated posteriorly on a small raised area on the ninth segment. The female genital (fig. 18) aperture is a longitudinal slit in both the eighth and ninth segments.

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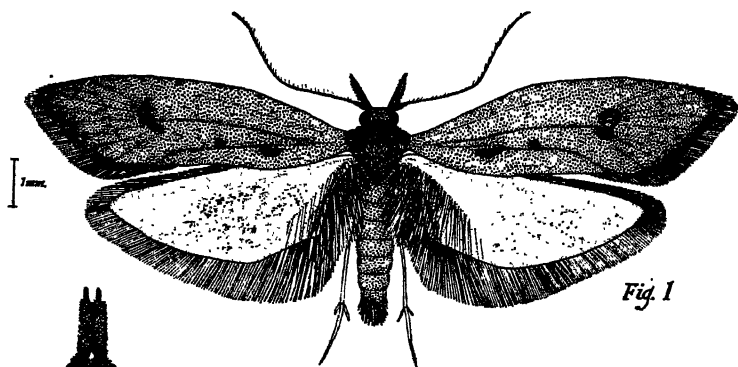
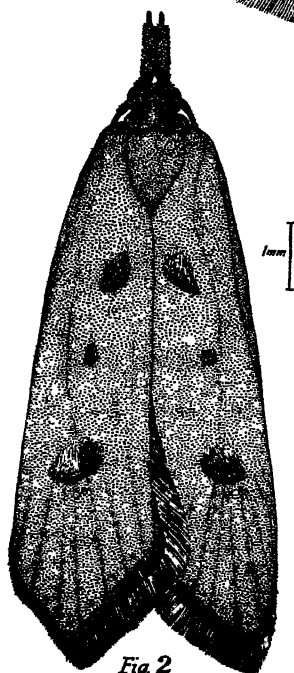
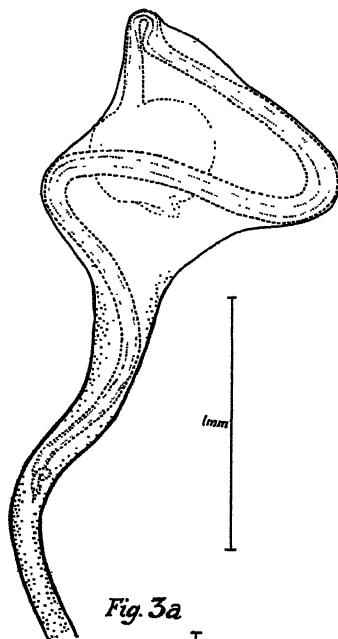
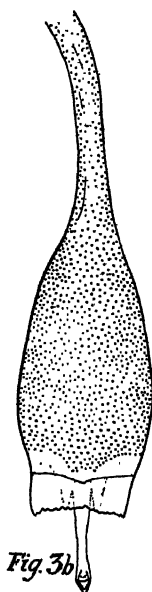
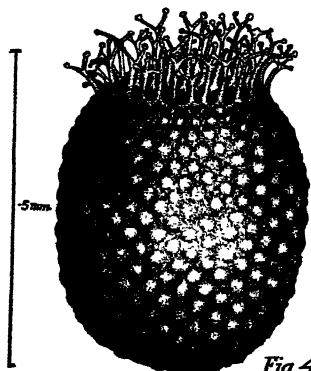
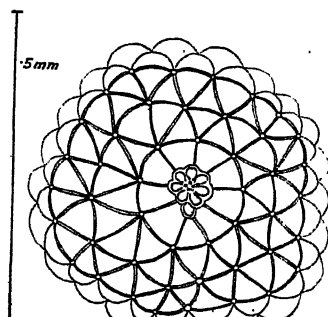
*Fig. 1**Fig. 2**Fig. 3a**Fig. 3b**Fig. 4**Fig. 5*

FIG. 1.—Moth ♂, with wings expanded. FIG. 2.—Moth with wings in natural rest position. FIG. 3a.—Bursa copulatrix. FIG. 3b.—Ductus bursa. FIG. 4.—Egg. FIG. 5.—Operculum of egg showing position of base of the spines.



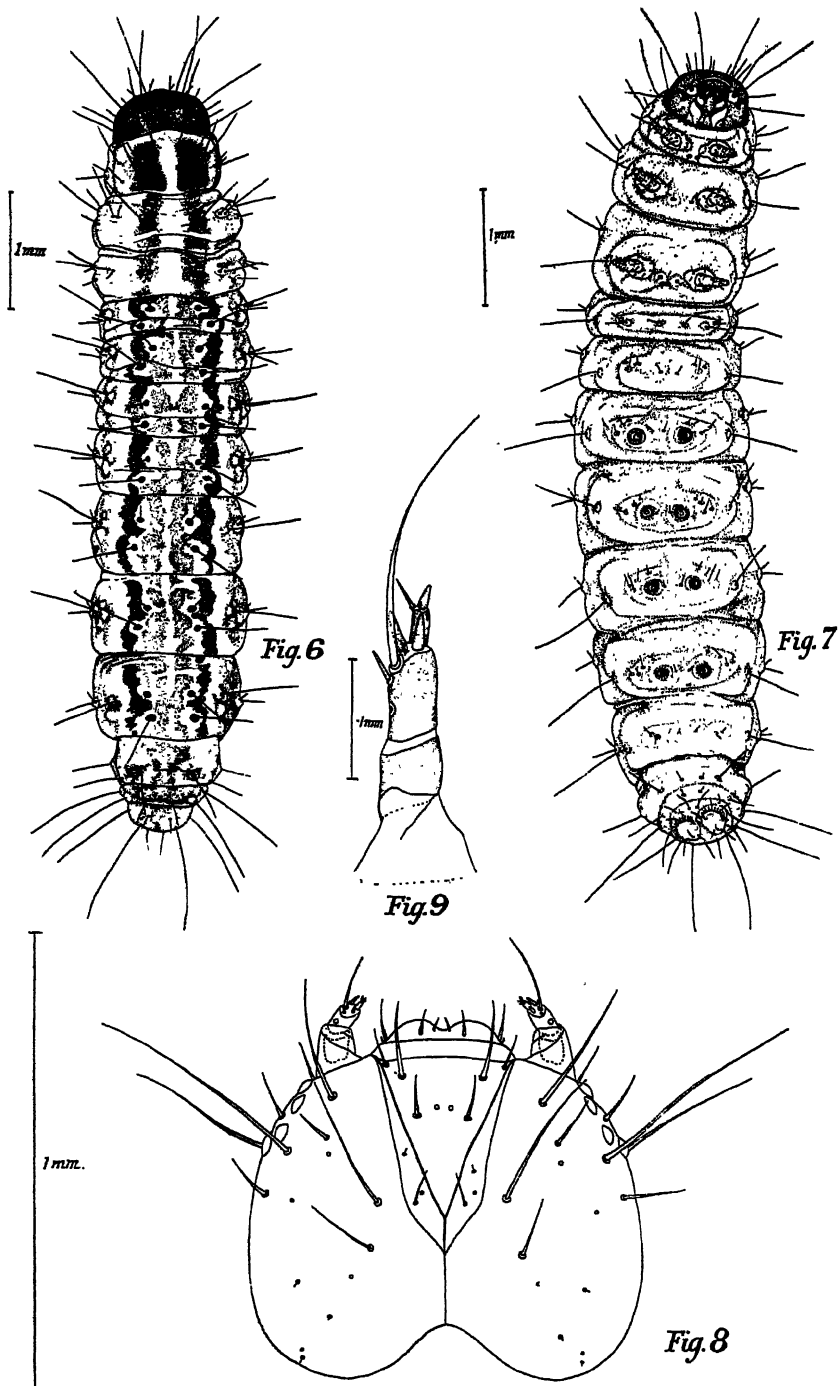


FIG. 6.—Dorsal view, final instar larva. FIG. 7.—Ventral view, final instar larva. FIG. 8.—Dorsal view, head of larva. FIG. 9.—Right antenna of larva, ventral view.



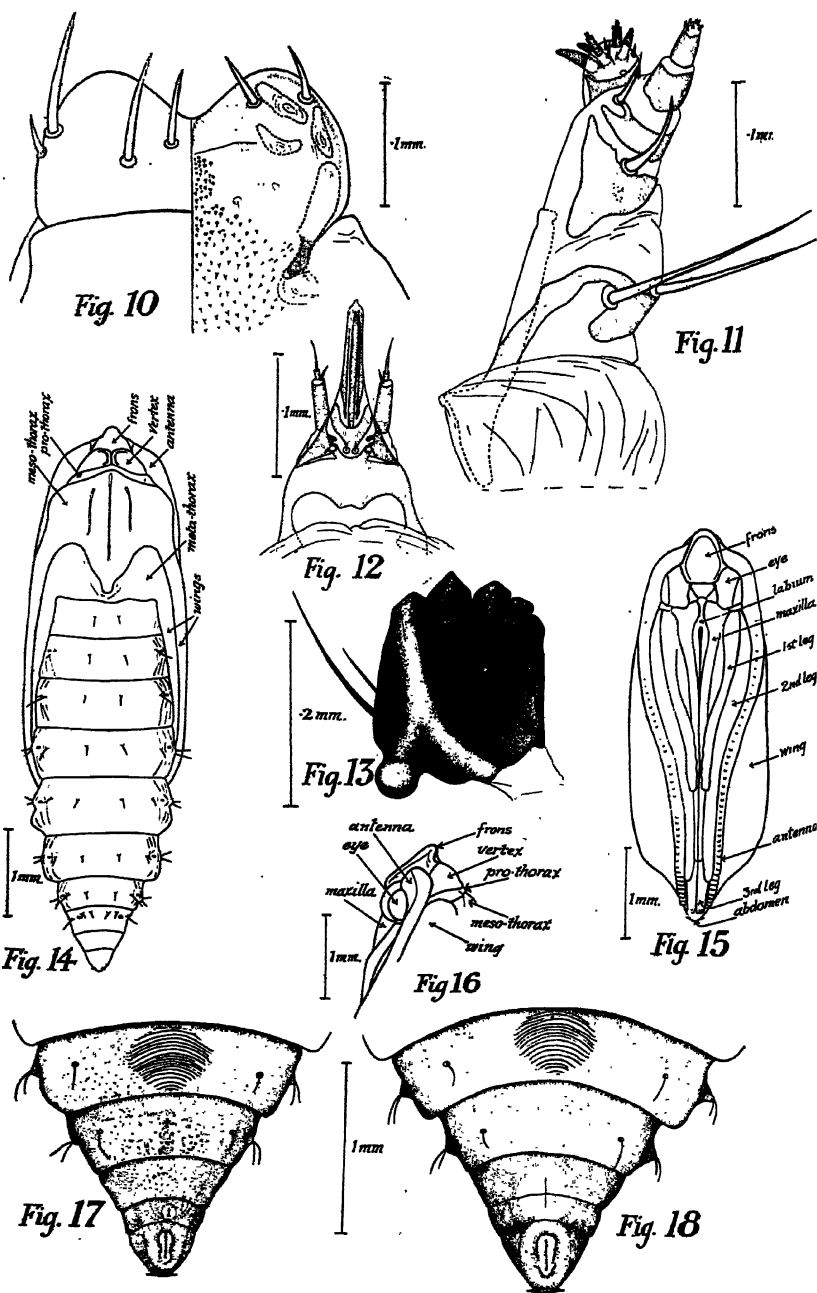


FIG. 10.—Labrum of larva, outside and inside surfaces. FIG. 11.—Left maxilla of larva, ventro-lateral view. FIG. 12.—Labium of larva. FIG. 13.—Right mandible of larva, ventral surface. FIG. 14.—Dorsal view of pupa (segments expanded). FIG. 15.—Ventral view of pupa (segments retracted). FIG. 16.—Lateral view, head of pupa. FIG. 17.—Ventral view segments 6-10, ♂ pupa. FIG. 18.—Ventral view segments 6-10, ♀ pupa. Figs. 17 and 18 expanded to show relative sizes of segments.



## *Hexatricha pulverulenta* Westwood.

By F. J. JEFFREYS, M.Sc., Cawthron Institute.

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*Hexatricha pulverulenta* Westwood is a small native longhorn found on *Nothofagus* and the exotic *Pinus radiata* throughout New Zealand. The following is a description of the external anatomy and reproductive organs with short notes on habits and life history.

My thanks are due to Dr. Miller, to Professor Kirk, who supervised the original work, and to Mr. L. J. Dumbleton, who has supplemented my observations on the life history.

### HABITS.

The pine tree (*P. radiata*) is attacked shortly after death. With her mandibles the female cuts in the bark a transverse oviposition hole 2–3 mm. deep, and deposits an egg between the bark and the wood; the egg is thrust down at right angles to the hole for several millimetres. If the bark is more than  $\frac{1}{4}$  inch in thickness the female chooses a fissure in which to make the oviposition hole, which is sealed by a secretion after deposition of the eggs. One egg is usually laid, although up to four have been found. In captivity the females never oviposited in a branch on the ground, but always preferred an upright one, the beetles in the field being found on the upright main stem. Eggs laid in the laboratory were found to hatch in 10 to 19 days, taking 10 days in hot weather; they have been found in the field from October to April.

The beetles with their powerful mandibles cut off shreds of bark, feed through adult life and eat more or less continuously in captivity. Beetles were observed to eat round the margin of a hole in the bark (e.g., enlarging an oviposition hole), and would rarely make a hole for themselves. They did not touch green pine needles, but when kept for a short time with only "manuka" (*Leptospermum scoparium*) twigs were found on dissection to contain green matter in the alimentary tract. They are reluctant fliers and were not observed in flight in the open. They stridulate when caught, making a squeaking noise, and when agitated wave their antennae around. The period of adult life is evidently fairly long, beetles having been kept in captivity for more than three months, from March to June. They have been observed in the field from October to April.

The young larvae bore shallow tunnels between the bark and the wood, and seem to prefer the bark; they were not observed to bore into the heart wood. The length of the larval life is not known, but it is probably 2–3 years. A freshly-hatched larva grew from 3 mm. to 10 mm. in 5 weeks, but a larger larva kept for several months did not grow appreciably; this may have been due to the fact that the conditions were not close enough to the normal state. The larvae were observed to undergo ecdysis, but the length of time between moults was not ascertained, as those kept for 6 months did not undergo more than one moult. The larvae appear to be able to exist in very dry bark, although they shrivel and become very short,

evidently living on their fat content. They prefer a moist environment, but if kept in very moist bark the mortality is high.

Pupation may occur in a shallow cell lined with coarse shreds of wood and excavated between the bark and wood, or in a vertical chamber 1-2 inches deep in the wood. Pupae have been found from mid-November to the end of February, the pupal period lasting 30 days. The adult emerges from an irregular hole in the bark. Cocoons of *Mesostenus albopictus* were found in the larval burrows, and this species probably parasitises the larva.

#### DESCRIPTION.

##### *Egg.*

The egg (fig. 40) is yellowish-white with an unsculptured chorion; it is elongate, being 3 mm. long by 1 mm. wide, and is usually flattened by the pressure of the bark.

##### *Larva.*

The mature larva, covered with bronze coloured setae, is smaller posteriorly, longish and slightly flattened more especially at the anterior end, and is white except for the brown head and the brownish anterior edge of the pronotum. The legs are vestigial, reduced to a ring of short setae, though ambulatory ampullae are developed. The size of the mature larvae varies, but some have been found up to 35 mm. in length and nearly 5 mm. across the prothorax. The larvae are negatively heliotropic.

##### *Head.*

The head (figs. 1, 2 and 8) is more or less oblong, with its sides converging posteriorly and the posterior end rounded; it is depressed, being about twice as wide as it is high, and is deeply imbedded in the prothorax, only the anterior, more strongly pigmented half being usually visible. The colour of the head is striking; the more heavily chitinized parts are a reddish-brown which on the very strongly chitinized areas becomes dark brown to blackish (e.g., the mandibles), while the less chitinized portions are bronze, and the membranes whitish. The hairs are bronze, the longer ones being brown.

*The labrum* is visible at the antero-dorsal surface of the head, is movable, and can be partly retracted beneath the clypeus. It is rounded anteriorly and widest medially, being nearly three times as wide as it is long. Anteriorly, it carries hairs which are shortest at the edge; posteriorly, it is slightly chitinized. On its ventral surface (fig. 7) are convergent hairs. Its posterior ventral corners are supported by a chitinous bar on either side, while the ventral surface is continuous posteriorly with the epipharynx.

*The epipharynx*, which is supported on either side by a chitinous rod, has a slightly chitinized area for a short distance along the median line.

*The clypeus* is only slightly chitinized; it is widest posteriorly, being attached to the epistoma for the entire width between the articulations of the mandibles; it carries no hairs.

*The frons* is roughly triangular, and is defined laterally by the frontal sutures which are distinct and extend forward to the antennal rings which they bisect; the rings are, therefore, open behind. The

frons is brown in colour, strongly chitinized at the *epistoma*, and is divided by an incomplete median suture on each side of which are eight setae.

The *epistoma*, which is not produced over the clypeus, carries three epistomal setae on either side.

Posteriorly, the dorsal surface of the head is covered by the *epicranial halves* which extend laterally and cover the sides of the head as well; they meet in the mid-line behind the frons, where there is an attachment for the superior retractor head muscles, and are fused down their entire length. Posteriorly the halves are rounded, being developed into a small point at the posterior end of the epicranial suture.

The *gena* on each side is shouldered, and carries a few long hairs; the single ocellus, situated on the anterior part of each gena, projects slightly and faces forward, while it is separated from the antennal ring by a fold of chitin.

The *antennae* are three-jointed, frail and short, the terminal segment being minute; the basal membrane is large, and each antenna is readily retractile into the antennal ring, which is broken behind by the frontal suture.

The *mandible* (figs. 3 and 4) is elongated, being one and a-half times as long as it is wide at the base, which is the most massive part; the apex is produced and a tooth is borne on the inside edge, anteriorly and dorsally. Some mandibles appear shorter and stouter in comparison, but in these cases the tips have been broken off. The cutting edge is oblique and short. The surface of the mandible is finely granulate and has a few wrinkles towards the base; one or two setae are carried on the outer face. There is a well-defined condyle on the ventral outside corner, which articulates against the smooth pleurostoma. The ginglymus is well developed on the dorsal edge.

On the ventral surface of the head, the *mentum* and *submentum* are not distinct. According to Craighead (2), the *cardo*, the *maxillary sclerite* (maxillary articulating area), and the *submentum* are fused for the entire distance between the ventral articulations of the mandibles. This fused area, which has been called the compound fused area in the following description, is barely chitinized and almost transparent; the muscles for the labium and maxillae can be seen through it.

The *labium* (figs. 5 and 6) proper consists of a median ligula, at the base of which are attached two fused labial stipes, each of which carries a two-jointed labial palp. The palps lie on either side of the ligula, and are bronze in colour, the intersegmental membranes white, carrying bronze hairs. The membrane joining the palp to the stipes carries a few hairs, while that joining the two joints of the palp has one or two. Laterally the stipes are bronze, but in the midline more or less transparent, and are carried by the mentum, or that portion of the compound fused area representing the mentum. The dorsal, or inside surface of the ligula, carries a few hairs; posteriorly it is continuous with the hypopharynx, which is supported by a narrow, slightly curved, chitinous bar on either side.

The *maxillae* (figs. 2 and 5) consist basally of the stipes, which are attached to the outer anterior portion of the compound fused area, and which bear distally the palpifers; the palpifer carries on the inside the lacinia, and on the outside the three-jointed palp.

At the base of the stipes is a bronze coloured, more strongly chitinized band, which is broader on the inner side than on the outer; a few hairs are carried just in front of this band. The palpifer is large, more strongly chitinized ventrally, and bronze in colour. The membrane attaching the lacinia and the palp to the palpifer carries a few hairs along its posterior edge.

The *lacinia* at its base is cylindrical and chitinized; distally it is swollen and more membranous, carrying a number of hairs. The segments of the palp become progressively smaller, the end one being less than half the width of the basal one; a few hairs are carried on the intersegmental membranes. Both the *maxillae* at the posterior ends of their stipes, together with the labium at the posterior end of its fused stipes, are retractable beneath the compound fused area; there are a few hairs carried on this area towards the anterior end, and four others spaced two on either side posteriorly. When the *maxillae* and the labium retract, the compound fused area bends in as far as the anterior row of hairs.

Anteriorly the *hypostoma* is fused to the compound fused area; medially it is fused with the gula, the gular suture being but a faint median line. The outer posterior corners of the hypostoma are developed into raised areas; about the centre of the outer side, the raised area ends in a rounded protuberance. *H. pulverulenta* is the only Lamiid in which this ridge has been found. Medially, it is not so steeply raised, the posterior side dipping down sharply to the occipital foramen. Setae are carried on either side of the gular suture, and anteriorly the line of these setae turns towards the anterior outside gular angle. There is a slight depression in the epicranium before it joins the hypostoma.

The *occipital foramen* is large, posterior and ventral. Round it is attached an extension of the prothoracic skin which forms a continuous band, the collar, attaching the head to the prothorax. This allows the head to be extended and retracted by the superior and inferior retractor muscles.

According to Craighead (2), there are certain characteristics which distinguish the Lamiinae from the rest of the Cerambycidae. The larval head of *H. pulverulenta* exhibits some of these characteristics well, for example: the oblong head; the fusion of the dorsal margins of the epicranial halves down their entire length; the elongated mandible; the epistoma not produced over the clypeus; the cardo, maxillary sclerite, and submentum fused; the antennae very retractile and small.

#### *Thorax.*

The *prothorax* is much the largest of the three thoracic segments, and across the pronotum is the widest part of the larva; the mesothorax is smaller than the metathorax.

The pronotum is a large rectangular plate, it is not fused with the alar area, but separated from it by the lateral suture, which is only present posteriorly. The anterior area of the pronotum is more or less chitinized, smooth and shining, carrying a few hairs anteriorly and laterally; the median area carries a few short hairs, while the posterior area is shining and smooth, except that it is broken by longitudinal striae. There is a narrow postnotal fold just behind the pronotum.

The protuberant fold along the side, the epipleurum, which represents only a portion of the adult pleurum, is well marked posteriorly, but it is less conspicuous in the thoracic segments.

The alar areas lie on either side of the notum. The epipleurum is separated from the pro-alar area by a narrow furrow, the dorso-lateral suture, and ventrally from the sternum by the ventro-lateral suture.

The presternum is well developed, forming anteriorly one large slightly chitinized plate. The eusternum is weakly defined, being roughly triangular in shape; behind it lies the narrow, smooth sternellum.

The *mesothorax* is very small, and the parts of the mesotergum not distinct. A spiracle is carried laterally at the anterior end of the alar area, above the epipleurum; this is the largest of the spiracles. The epipleurum can be distinguished, and the hypopleurum is not definitely defined.

The sternum is divided by a median transverse line, round which are developed small protuberances similar to the ampullae of the abdominal segments, except that the protuberant area is much narrower. The ambulatory ampullae are described later.

In the *metathorax* the different structures of the tergum are obscured as ampullae are developed. Laterally the alar area is not well defined. The presternum is fused with the anterior part of the epipleurum. The hypopleurum is not definitely distinguishable and the sternum is developed medially into ampullae.

The small circles of short spikes representing the vestigial legs are carried on either side of the sternellum in the prothorax, and of the sterna in the mesothorax and metathorax.

#### *Abdomen.*

The nine abdominal segments are shortest anteriorly; the first four or five become progressively rounded and longer, the remainder becoming slightly smaller to the small ninth segment. The tenth segment, according to Craighead (2), is probably represented by the anal lobes. In the abdomen the epipleura are protuberant and separate the segments into dorsal and ventral regions. Craighead considers that these regions can be divided into certain areas, some of which are homologous with the thoracic areas, and are similarly named; others are questionably homologizable, and others again are special abdominal developments. In the latter two cases Craighead has applied new names.

The epipleurum is protuberant on all the segments, more strongly so on the last few, especially the two terminal ones. There is a pleural tubercle on each epipleurum, except in the ninth abdominal segment; the tubercle is oval and lies obliquely, the anterior end being more ventral in position than the dorsal. The number of setae each tubercle carries varies—the first usually with two, the rest progressively with more, the last carrying up to twenty; some of the setae are short and bristle like, others are much longer.

The dorsal and ventral protuberances on the first seven segments are called the ambulatory ampullae, and are used by the larvae in moving in the burrows; they are irregularly tuberculate, and a longitudinal depression divides each ampulla into two lobes. The tubercles, which have a shining surface and carry no hairs, are arranged round a transverse depression which in the anterior ampullae is narrow; in the posterior ones, at the outer ends, it broadens; dorsally, especially in the posterior segments, this transverse depression is obscured, there being three or four rows of irregular tubercles. The ampullae are formed from a dorsal protuberance of the prescutum, scutal plate, parascutum, and scutellum, and from a ventral protuberance of the eusternum and sternellum.

The scutal plate is not well defined. In front of it is the ill-defined prescutum, and behind, the scutellum. The parascutum lies on the side and is also not well defined; below it and above the epipleurum lies the spiracular area, the ventral limit of which is well defined. There is a small depression lying between the parascutum and the spiracular area. The spiracle lies slightly towards the anterior end of the surface of the spiracular area, and is not on a protuberance. Ventrally the different parts are not easily distinguishable. The presternum is not separated from the epipleurum, and appears as an anterior ventral extension of the epipleurum. The ventral ampullae are divided by a transverse depression. The eusternum is the region in front of the line, and the sternellum the region behind. These are fused laterally with the coxal lobe and hypopleurum, which are not definitely defined, but which lie directly below the epipleurum.

The ninth abdominal segment is partly retracted into the eighth. On either side of the tergum is a small depression. The anal lobes surround the anus, a median dorsal and two others latero-ventral in position. These lobes carry setae.

The dorsal and ventral wedge-shaped perpendicular bands developed in the intersegmental membranes, the dorsal and ventral cunei, are fairly wide. The ventral cuneus is situated behind the dorsal, thus allowing a large amount of movement between the segments. In the thorax the cunei lie in the same plane so that little extension is possible.

#### *Pupa (fig. 11).*

##### *Head.*

The head is bent at right angles to the body, the mouth parts lying over the pair of prothoracic legs. The tips of the mandibles are the only strongly chitinized parts. Hairs are developed on the labrum and are visible through the membrane.

The compound eyes have reached an advanced stage of development, their outlines being plainly visible. The membrane above the frons and the eyes carries three or four setae which are borne on small papillae. The membrane directly above the gena carries two setae; that covering the clypeus carries the two lots of three epistomal setae.

The palps of the labium and maxillae are not fully developed. They extend beyond the mandibles, the segments being more or less visible. The ligula appears as two fused rounded processes. The antennae, which are carried at the anterior end of the head on slightly raised processes, are eleven jointed. They are recurved so that their extremities reach almost to the level of the beginning of their third segment; the long hairs carried by the adult antennae are not yet fully developed.

#### *Thorax.*

The prothorax is the largest of the three thoracic segments, as in the larva and adult. On the membrane covering it are carried an anterior row of setae, and median and posterior areas with setae.

The mesothoracic spiracle lies laterally between the pro- and mesothorax. The elytra are on either side of the mesothorax; they are directed outwards and backwards and are not fully developed, although they carry hairs on their outer ends. The outline of the mesonotum can be discerned and is slightly raised posteriorly; a row of setae is carried on the membrane covering the posterior raised portion. The mesothorax is the smallest of the three thoracic segments.

Laterally the metathorax carries the wings which lie below and behind the elytra; they appear fleshy and are not a quarter of their final length. The different parts of the metanotum are not distinct except for the metascutellum, which is distinguishable as a median dark band, narrower posteriorly. A few setae are carried laterally on the pupal integument above the metanotum.

The legs are comparatively far advanced in their development. The coxa, trochanter, femur, tibia, and tarsus are all distinct. The tarsus is five-jointed, and the tarsal pads are developed. Hairs are also carried on the other segments. The claws and tibial spines are developed but not chitinated. The legs are folded ventrally, the junction of the femur and tibia being posterior, that of the tibia and tarsus anterior, the tarsus lying parallel to the mid-ventral line. On the integument covering each femur are a few scattered setae, while others are arranged in a row at the posterior end.

#### *Abdomen.*

The abdomen has nine segments plainly visible; the tenth is small and more difficult to determine. The dorsal integument carries an anterior and a posterior row of spines, as well as a few setae on each segment, more especially on the posterior ones. The seventh tergum is the largest.

The first abdominal spiracle is large, as in the adult, the remaining eight are small. The integument covering the pleura is very wrinkled, and that covering the sterna is smooth and free from spines

or setae. Anteriorly the first two abdominal sterna are represented by folds in the membrane. The third sternum is very large and the next three are smaller, the seventh being slightly larger again.

The eighth segment, which carries a spiracle not functional in the adult, is very much smaller than the seventh, while the ninth is smaller still. The sterna of the eighth and ninth segments are divided by an incomplete median longitudinal line.

The ninth segment dorsally carries a well-developed spine on the tergum, and laterally and ventrally has short spines as well as setae on the swollen pleural region.

Ventrally the beginning of the genital invagination (figs. 9 and 10) can be seen between the ninth and tenth sterna. On the ninth sterna posteriorly are developed two papillae which help to form the ventral lip of the invagination. The tenth segment is small and is terminal in position, the dorsal portion carrying two spines, and the ventral portion forming the dorsal lip of the invagination. The integument is very wrinkled between the dorsal and ventral portions of the tenth segment.

The eighth, ninth and tenth segments are invaginated in the adult, the ninth and possibly portions of the eighth, helping to form part of the adult genitalia. The tenth may also help or, more probably, it is totally missing.

#### *Imago.*

The beetle (fig. 12) varies in size from 13 mm. to 21.5 mm. in length, the measurements being taken from the tip of the mandibles to the ends of the elytra; the average length is about 19 mm., and the females are slightly broader than the males. The insect is strikingly marked with yellowish-white and blackish-brown hairs. *Head* (figs. 15, 18 and 19).

The head is a strongly chitinated capsule with most of the sclerites fused and only a few sutures showing. The epicranial suture is complete, and terminates in a pointed process at the dorsal surface of the occipital foramen. Hairs cover the head in patches; the chitin is blackish-brown and the hair patches yellowish, giving a mottled appearance to the head.

The vertex is depressed and the antennae are borne on slightly raised processes, which are surrounded by the eyes on the outer side. The post-clypeus is fused with the greatly reduced frons. The ante-clypeus is membranous and bears long hairs. The gena on either side is slightly swollen posteriorly to the junction with the clypeus; between this swelling and the junction it bears a facet for the articulation of the ginglymus of the mandible and ventrally a cavity for the condyle of the mandible of that side. The genae do not meet ventrally, being separated by the gula. The latter is broader posteriorly, narrows slightly and then broadens out anteriorly; posteriorly it is separated from the genae by the gular sutures, and anteriorly bends downwards forming a depression before it curves forwards to carry the submentum. The occipital area has two indented lobes dorsally.

The eyes are convex, crescentic in outline, and constricted medially; they curve round the base of the antennae posteriorly and come together more closely dorsally than anteriorly. There are hairs round

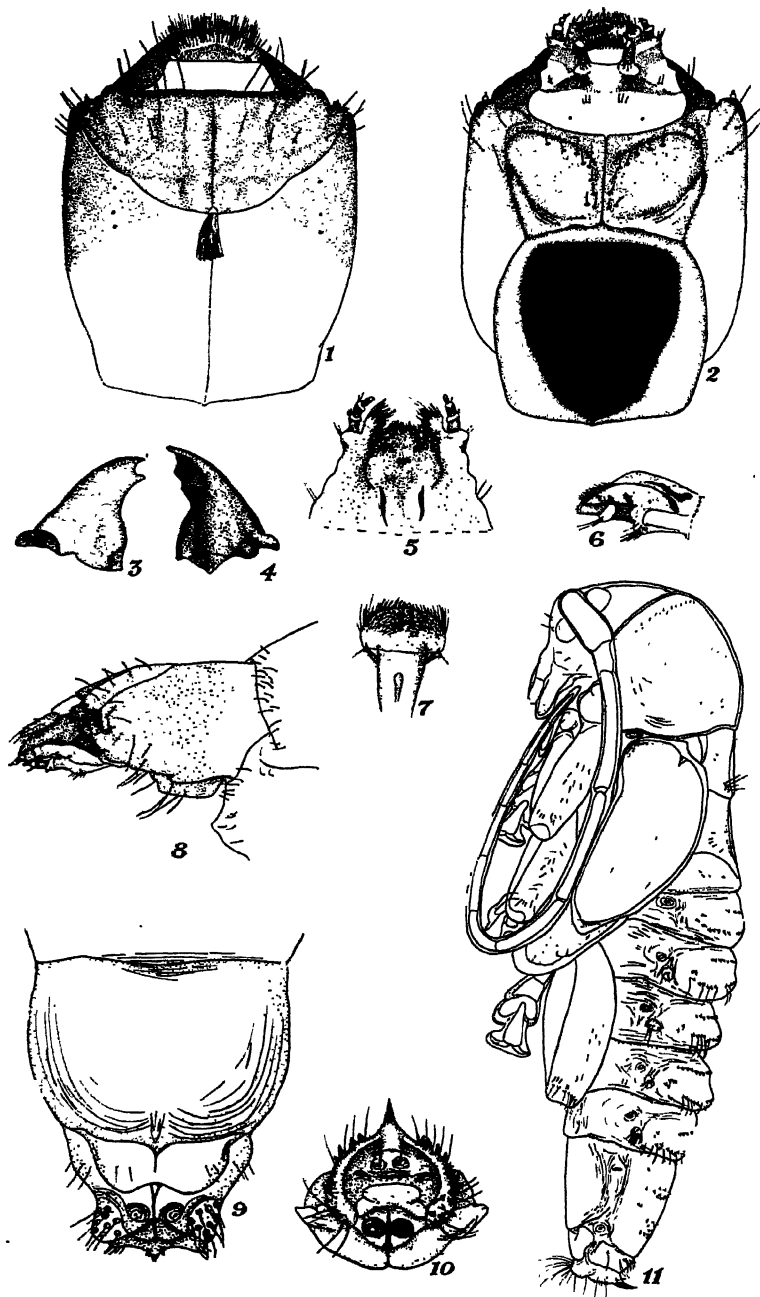


FIG. 1.—Larva: head, dorsal view. FIG. 2.—Larva: head, ventral view. FIG. 3.—Larva: left mandible, dorsal view. FIG. 4.—Larva: left mandible, ventral view. FIG. 5.—Larva: labium, maxillae and hypopharynx, dorsal view. FIG. 6.—Larva: labium, side view. FIG. 7.—Larva: labrum and epipharynx, ventral view. FIG. 8.—Larva: head, side view. FIG. 9.—Pupa: last segments of abdomen, ventral view. FIG. 10.—Pupa: head, side view. FIG. 11.—Pupa: left side of pupa.



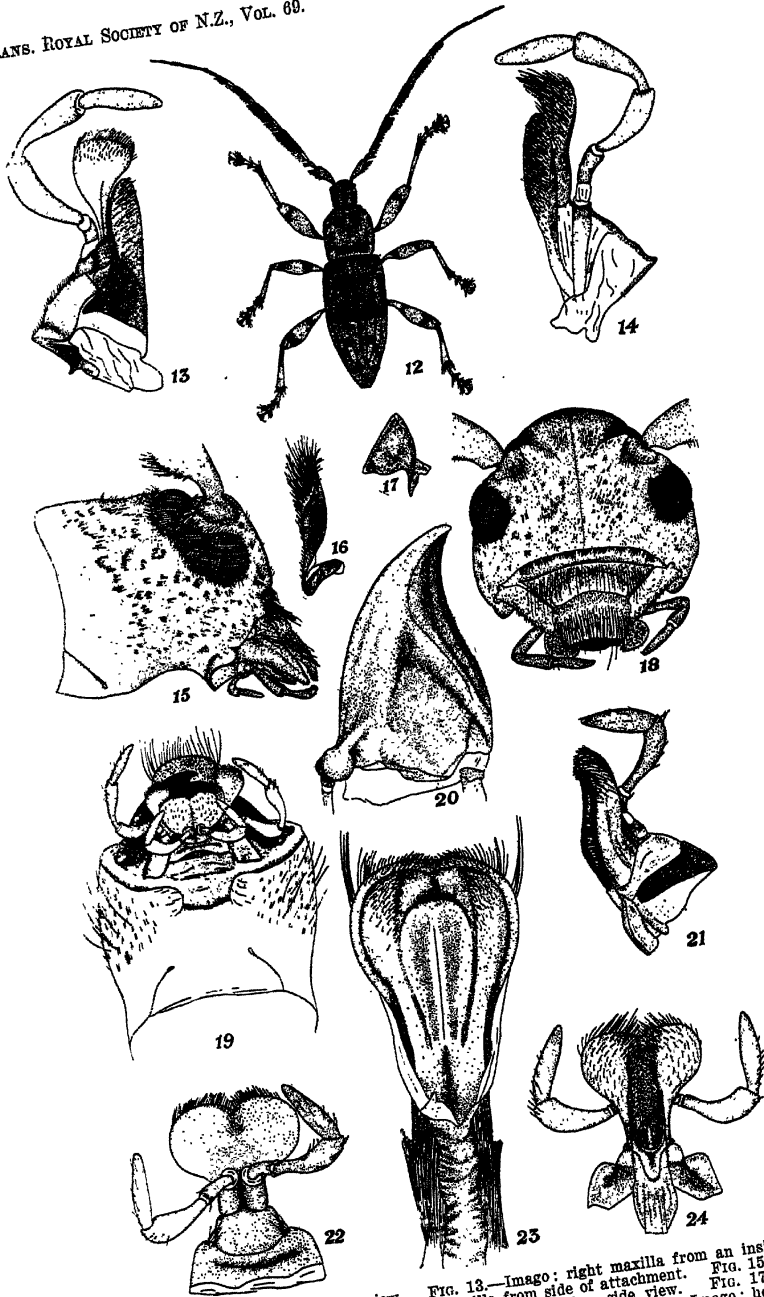


FIG. 12.—Imago: male, dorsal view. FIG. 13.—Imago: right maxilla from an inside ventral aspect. FIG. 14.—Imago: right maxilla from side of attachment. FIG. 15.—Imago: side view of head. FIG. 16.—Imago: right galea, side view. FIG. 17.—Imago: head, anterior view. FIG. 18.—Imago: head, ventral view. FIG. 19.—Imago: head, side view. FIG. 20.—Imago: right mandible, ventral view. FIG. 21.—Imago: labium, ventral view. FIG. 22.—Imago: labium, side view. FIG. 23.—Imago: labium and epipharynx, ventral view. FIG. 24.—Imago: labium and hypopharynx, dorsal view.



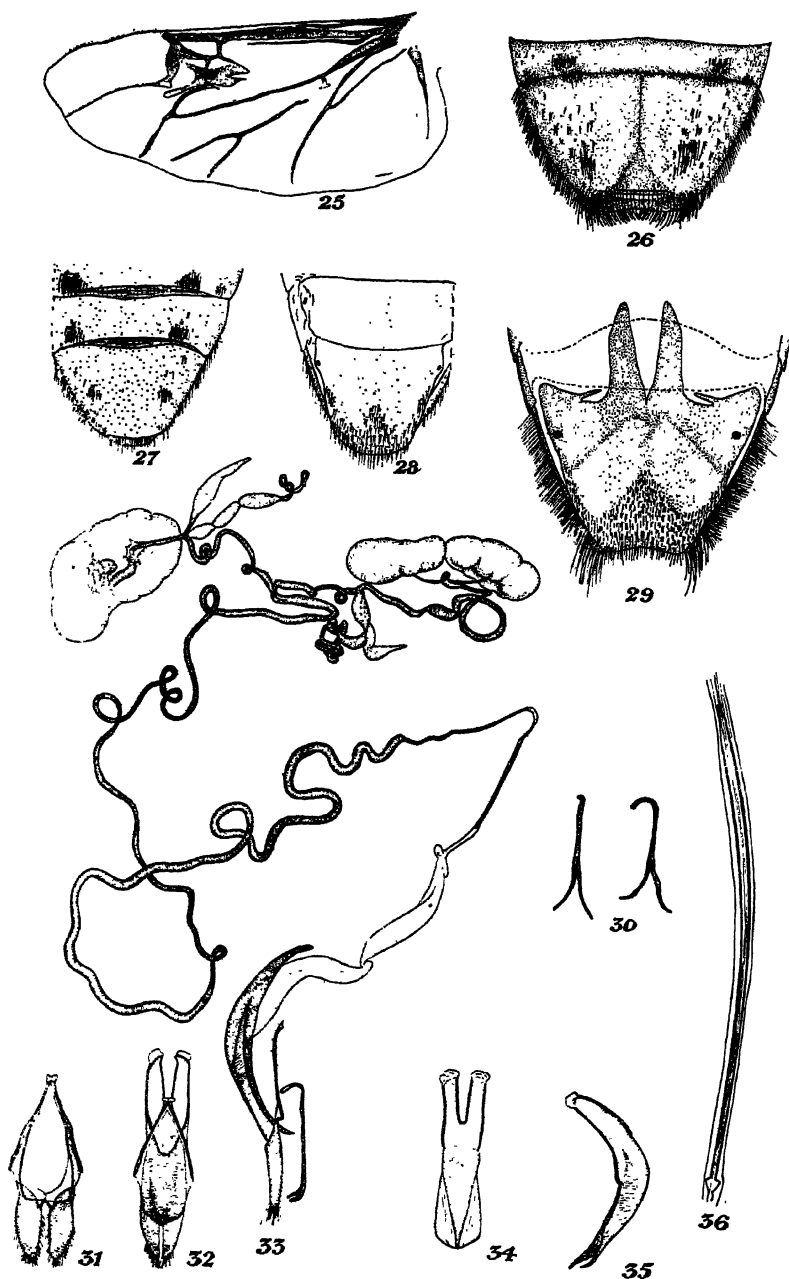


FIG. 25.—Left wing. FIG. 26.—6th and 7th abdominal stergum of female, ventral. FIG. 27.—6th and 7th abdominal stergum of male, dorsal. FIG. 28.—6th and 7th segments of abdomen of male, ventral. FIG. 29.—7th segment of abdomen of female, dorsal. FIG. 30.—Spicula gastralia, ventral. FIG. 31.—Tegmen, dorsal. FIG. 32.—Ventral view of tegmen and median lobe in natural position. FIG. 33.—Male reproductive system. FIG. 34.—Median lobe, dorsal. FIG. 35.—Median lobe, left side. FIG. 36.—Chitinous rods.



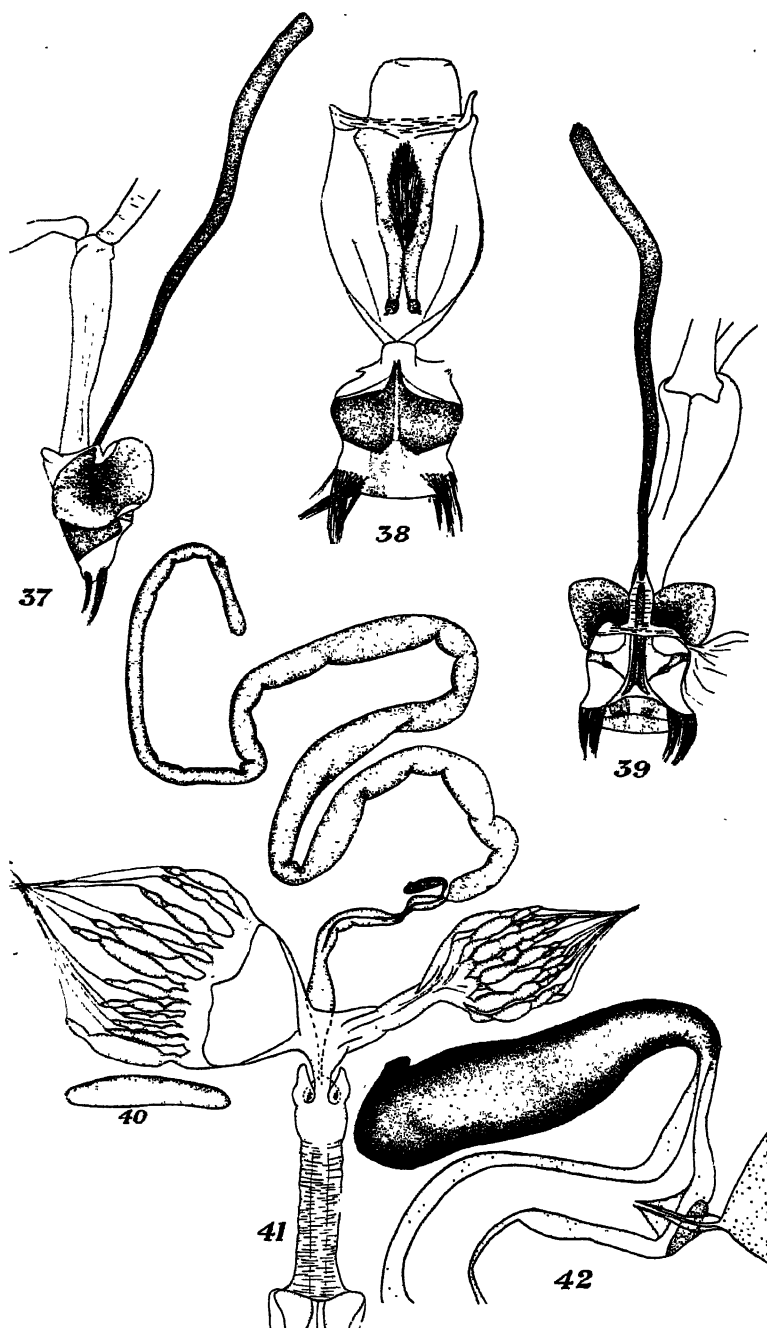


FIG. 37.—Ovipositor, from left side. FIG. 38.—Ovipositor, dorsal, membranous tube slit up to expose end of ovipositor retracted within. Anus and rectum cut across to show anterior ends of coxites and vagina attachment to membranous tube. FIG. 39.—Ovipositor, ventral. FIG. 40.—Egg. FIG. 41.—Female reproductive system—right oviduct slit up, ventral view. FIG. 42.—Spermatheca and portion of the bursa copulatrix.





the margin giving the appearance of eye lashes; these are most strongly developed ventrally and postero-dorsally as well as anteriorly in the median line. The ommatidia are hexagonal and uniform.

The antennae are very long, longer than the body, and typically eleven-jointed. The scape is the thickest, the pedicle shortest, and the third joint longest. The first six segments, especially the first four of the flagellum, carry long setae posteriorly along their length. The basal colour of the antennae is a blackish brown, but white, yellow, brown, and black hairs arranged in bands give the antennae the characteristic banded appearance. The clothing hairs of the scape are brown, those of the pedicel blackish-brown, while the long setae on the scape are yellowish and on the pedicel black. In the next four joints, the clothing hairs proximally are white, and distally brownish-black; the long setae are proximally yellow, and distally black. The seventh joint carries a few long setae on the proximal posterior border; these setae are not as long as those of the other joints. The last five joints exhibit the same basal colour, becoming a little lighter toward the extremity; they are covered with short clothing hairs which are white at the base but otherwise blackish-brown. The joints are progressively shorter from the third to the eleventh, the latter being rounded at its tip; all articulate with their neighbours except the pedicle, which appears fused to the third joint. The scape articulates with the head by means of the antennary socket.

The lateral anterior inner parts of the *labrum* bear setae as well as the external portion. On the inside the median section is raised to form the *epipharynx* (fig. 23), the sides of which are supported by chitinous rods posteriorly.

The *mandibles* (fig. 20) are well developed, strong, hollow and curved, with a sharp cutting inner edge slightly serrated, and a broader outer edge which carries hairs; there is no tooth as in the larval mandible. The condyle is well developed and articulates in the socket of the gena which is ventro-laterally placed. The fronto-clypeal facet for the ginglymus is dorso-lateral. Both dorsal and ventral surfaces of the mandible are smooth; on the dorsal surface near the base of the inner margin of the mandible there is a small hollow or pit filled with short hairs; there is no crushing area. The mandibles are used for cutting the bark scissor-fashion and evidently the small pieces shredded off do not undergo further mastication, the gut being found to contain comparatively large pieces.

Each *maxilla* (figs. 13, 14 and 17) consists of a basal *cardo* (fig. 17) which is completely hidden from view when the parts are lying *in situ*; it is narrower basally and has a half turn, the line of attachment to the head being at right angles to the line of attachment to the stipes. The stipes is visible ventrally when the parts are *in situ*; it is roughly a rectangle and hairs are present along its outer margin. Antero-laterally the stipes carries the palpifer which bears the four-segmented palp; the connecting membranes are white and the joints of the palp blackish brown with comparatively few setae; this absence of setae is an unusual feature; the basal joint is the shortest, the next two the longest and broadened anteriorly, while the terminal one is obtusely pointed.

The stipes bears the two-pointed galea between the lacinia and the palpifer. The proximal portion or the blade of the galea (fig. 16) is narrower and triangular in cross section, while distally it broadens and flattens; it bears numerous hairs on the anterior end of the outer surface. The sub-galea is at right angles to the blade.

The distal portion of the lacinia, which is in two parts, has long hairs and is carried by the basal portion which is partly fused to the outer border of the sub-galea.

The *labium* (figs. 21, 22, and 24) consists of a mentum (Imms 3) or a submentum (Tillyard 10) bearing anteriorly two labial palpigers which carry the three-joined labial palps, the terminal joint of which is obtusely pointed; there are a few setae on all three joints. Joining the palpigers to the mentum is a slightly chitinized membrane hidden from view by the mentum when the parts are lying in their normal position.

The *ligula* is bilobed and flat anteriorly; it carries a few hairs on the ventral surface, while anteriorly, in the mid-line of the inner surface, there are numerous setae, which are shorter and denser posteriorly.

The *hypopharynx* anteriorly is a smooth median process on the floor of the mouth; posteriorly it widens and becomes more membranous.

#### *Wings.*

The hind wings (fig. 25) are membranous and transparent, nearly half as wide as long, and when fully extended as in flight they are about four-fifths of the total length of the whole insect; they are covered by minute spines, longer along the posterior margin.

The venation of the wing follows the Cantharid type. The veins present are Costa, Subcosta, Radius, Radial sector, and  $R_{2+3}$ ,  $R_{4+5}$ ,  $M_{1+2}$ , Cubitus,  $Cu_{1+2}$ , Anal,  $A_{1+2}$ ,  $A_{3+4}$ , and certain cross veins,  $m-cu$  being incomplete. The costa is reduced, being present only at the humeral angle, while the subcosta extends for about a third of the wing length.

$R_1$  is a large convex vein which runs more than two-thirds of the way down; a small vein is given off posteriorly to it which is presumably the radial sector;  $R_2$  appears as a recurrent branch of the radius;  $M_1$  and  $M_2$  coalesce distally forming a loop (Cantharid type), and  $M_2$  continues to the wing margin; the cubitus is incomplete, only the distal portion remaining with  $Cu_1$ , and  $Cu_2$  continuing towards the margin; the proximal end of the media is thickened, which may represent the fusion of  $M$  and  $Cu$  at their basal ends; three anal veins are present at the base of the wing. Halfway down the length of  $A_1$ ,  $A_2$  either coalesces with it, or is joined by a cross vein to it, in which case the rest of  $A_2$  is missing.  $A_3$  is very broad at the base, narrows distally, but does not reach the wing margin. There is a small fragmentary transverse vein given off from  $M$  which is probably  $m-cu$ ; in some wings it is attached to  $M$ , in others it is free, but its other end is branched and is thus T-shaped. Between  $R_2$  and  $M_1$  there are several reduced veins. It was not possible to trace the development of the wings, so it cannot be said with certainty

which veins the reduced ones represent. Probably the vein running to the margin is the distal end of  $R_{.4}$  or represents  $R_{.4}$  and  $5$ , and  $R_{.3}$  is the fragmentary vein lying between  $R_{.2}$  and  $M_{.1}$ . If this is the case, there are then cross veins  $r_{.1}-r_{.2}$ ,  $r_{.2}-r_{.3}$ , and  $r_{.3}-m_{.1}$ .

#### *Abdomen.*

There are seven visible terga and five visible sterna in the abdomen. In the male a terminal segment is retracted within the abdomen, and in the female one or more of the terminal segments go to form part of the ovipositor. In the female the seventh tergite (fig. 29) is much larger than that of the male (fig. 28); it is as strongly chitinised as in the male, and there are two antero-medial processes which lie below the tergites of the preceding segments and to which muscles of the ovipositor are attached. The seventh sternite (fig. 26) is much broader and longer than that of the male (fig. 27); there is a median longitudinal furrow which widens posteriorly and which is absent in the male, a character giving the easiest method of distinguishing the sexes.

#### *The Male Reproductive Organs* (fig. 33).

*The testes* are paired, and in each, held together by a membrane, there are two lobes which are round flattened bodies, the centre being thinner than the sides. The greatly coiled *vas deferens*, formed by the union of the two small *vasa efferentia* which leave the inner hollowed centre of each lobe of the testes, lies between the lobes and leaves the surrounding membrane about the point where it is joined by the accessory gland and seminal vesicle. In *Saperda carcharias*, belonging to the same sub-family, instead of a separate *vas efferens* for each lobe there is only one which passes through the second lobe.

*The accessory gland*, a comparatively small, blind structure with the anterior end bluntly pointed, is slightly swollen before it narrows and joins the *vas deferens*.

*The seminal vesicle* is very narrow anteriorly and greatly coiled, but before joining the *vas deferens* it swells out and is usually twisted three or four times.

*The ejaculatory duct*, greatly coiled and very long, is surrounded by a thick muscular coat posteriorly. Near its termination it is supported by two chitinous rods (fig. 36) which are long, round, and narrow, being attached at their basal ends to the beginning of the internal sac into which they project; these rods are evidently structures for strengthening the protrusile end of the ejaculatory duct, and presumably form the transfer apparatus.

*The internal sac*, a very long structure, lined with patches of small spines, is divided into three parts by two well-marked transverse folds, the anterior part being very narrow and the two posterior ones much larger. The beginning of the second part is slightly bulbous, and muscles are attached to it. The third part is nearly equal in length to the other two together, and widens to about three times its original width before the attachment of its posterior end to the inside posterior end of the median lobe, where it opens to the exterior through the median orifice. In the 2nd and 3rd parts, dorsally and

ventrally, there are two longitudinal bands of granular thickening which narrow at the transverse fold between the two parts and which terminate about halfway down the third part.

*The median lobe* (figs. 32, 34 and 35), a curved hollow structure with a pair of anterior struts, is formed by a dorsal and a more strongly thickened ventral sclerite which join latero-anteriorly, and are connected latero-posteriorly by a slightly chitinized membrane. The ventral sclerite is much broader than the dorsal, and not so curved. The internal sac enters the median lobe through a median ventral foramen over which the two struts curve dorsally, the ventral sclerite passing up on either side of the foramen to join the dorsal sclerite. The internal sac is attached internally to the posterior end of the median lobe separating the two sclerites, each of which forms a lip to the median orifice. The internal sac is not attached to the extreme tip of the ventral sclerite, which forms consequently a more marked lip towards which the tip of the dorsal sclerite curves down. When the internal sac is everted the two sclerites are forced apart to allow the internal sac to be pushed through.

*The tegmen* (figs. 31 and 32) surrounding the median lobe is ring-shaped with a pair of well-developed lateral lobes carrying a few stiff hairs on their distal ends. The basal piece has possibly fused with these lobes and is not developed to the extent that it is in *S. carcharias*; basally to this the lateral lobes are joined. To the outside of lateral projections of the basal piece extending inwards, but not meeting in the midline, are attached a pair of ventral struts which meet basally; these struts are comparable with the stout chitinous arch described by Ritchie (5). The lateral projections and dorsal fused parts appear to be all that are chitinized of the basal piece. According to Sharp (7) the chitinized condition of some parts is secondary to the membranous condition; if this were to hold for the basal piece it might be that the ventral part is membranous, and thus the membranous basal piece would be in the same position as the chitinized basal piece of *S. carcharias*. There would be no distinction between the membranous basal piece and the second connecting membrane.

*The spiculum gastrale* (fig. 30), a curved chitinous rod forked posteriorly, but varying in shape in different individuals, is found lying below the median lobe and the tegmen. The anterior end is abruptly curved towards the dorsal surface or, more usually, slightly to one side; the posterior end is bi-fid and bends towards the dorsal surface.

*The Female Reproductive Organs* (fig. 41).

The two ovaries, one on either side of the abdomen consist each of twelve egg tubes, each tube ending in a terminal chamber which is bottle-shaped and has a filament at its apex; these filaments come together at a distance away from the end cells of about half the length of the tubules. The ovaries are arranged in a circle, and open into the swollen end of the comparatively short oviduct.

The thin-walled *accessory gland* is a long coiled tube, narrowing anteriorly to an obtuse apex. The secretion which entirely fills the cavity is probably that which is used by the female in sealing the

oviposition holes. The opening of the narrow chitinous tube which connects the gland to the *bursa copulatrix* is situated at the apex of a protuberance projecting into the latter.

The *spermatheca* (fig. 42) is a round, short, blunt, chitinous tube with a very narrow duct at right angles to it which connects it to the thick-walled *bursa copulatrix*. The inner surface of the *spermatheca* is produced into spines, and the cavity is often completely filled with sperms. The *spermatheca* runs parallel to the *bursa copulatrix*, to which it is attached by muscles, especially at its free end.

The *bursa copulatrix*, the walls of which are very muscular, narrows slightly, coils three or four times when it straightens out and becomes gradually much wider, while at the same time the wall becomes thinner and less muscular, though there is a strong muscular investment for the full length. The *bursa copulatrix* lies between the oviducts, and, narrowing, enters the vagina dorsally.

The oviducts pass above, and lie between, the muscles which originate on the head of the *spiculum ventrale*, and which are attached to the anterior fold of the membranous tube of the ovipositor. The ducts join ventrally in the median line, to form the common oviduct lying between the *spiculum ventrale* and the ovipositor.

The beginning of the *vagina* is the widest portion of it; ventrally, from the sides of this wider part, there are given off a pair of membranous flaps, each of which has a slight chitinous thickening at its base towards its ventral corner; the common oviduct enters ventrally between these flaps, while the *bursa copulatrix* enters dorsally at the same level.

There is a great development of muscles round the beginning of the *vagina*; muscles to the ovipositor are attached to it, the ear-like membranous flaps giving a greater area for attachment. The *vagina* curves, and turns forwards, to recurve and enter the ovipositor; it continues for a short distance before it opens between the ends of the ovipositor.

The *ovipositor* (figs. 37, 38 and 39) consists of a folded membranous tube, and of several associated sclerites which form a sheath round the posterior end of the membranous part. The apex of the ovipositor consists of two slightly chitinated protuberances, probably the coxites described by Tanner (9); their ends are more strongly chitinated and each carries a tuft of short hairs. These hairs, or the more strongly chitinated tips of the coxites, may represent the styli described by Tanner and Verhoeff (11). Halfway down the length of the coxites, and between the two, there is a membranous flap (presumably the vulva described by Tannar) which protects the opening of the *vagina*. These processes or coxites are continuous with the membranous tube, the tube being folded at the point where they are attached to it. The anal opening is found dorsally above the coxites. There are certain tufts of short bristle-like hairs on the dorsal and ventral surfaces of the coxites beyond the opening of the *vagina*. There are also long narrow hairs on the inner margins of the coxites, and on the membrane between the two coxites covering the *vagina*. The tip of the ovipositor is capable of being pushed out between the more greatly chitinated sheath of the posterior part.

The large dorsal sclerites of the sheath of the ovipositor are united in the median line by a less strongly chitinized membrane. They pass round the side and become much narrower, their ventral portion being very slight. There is a thin rod-like area which is more strongly chitinized, and which lies on either side of the mid-ventral line.

The saddle-shaped lateral sclerites are most strongly chitinized and are attached medially, on their inner surface, to the dorsal sclerites. They are thickest medially, and ventrally spread out slightly, but do not meet each other. The membrane which is attached to the last sternite and tergite of the abdomen is attached at its other end to the posterior margins of the lateral sclerites. From these sclerites numerous muscles arise.

Ventrally there is a rod-like sclerite in the median line with a slight fork at its posterior end. The dorsal and the ventral sclerites are formed into a continuous sheath by membrane; in this membrane there is a pair of longitudinal bands more strongly pigmented than the surrounding membrane. Near the posterior end of this membranous tube there are certain areas on which numerous setae are carried.

The chitinous rod (Ritchie) or *spiculum ventrale* (Verhoeff) (11) and Schedl (6) extends into the abdominal cavity, passing from the ventral towards the dorsal surface inwards, and reaching into the metathorax; this rod is hollow posteriorly, and opens to the exterior on the ventral surface, where it is covered by a membranous fold or pocket. The *spiculum ventrale* varies in shape in different specimens; it is usually not quite straight, and sometimes has a more strongly marked head, but in all cases it is of the same relative length to that of the body of the insect.

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## Breeding Habits of the Fishes of Otago Harbour and Adjacent Seas.

By DAVID H. GRAHAM, F.R.M.S., F.R.Z.S.

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### INTRODUCTION.

THE application of science to the fishing industry must be founded on a complete knowledge of the life history of each species of fish. The present notes, necessarily incomplete and even in parts fragmentary, are the result of observations carried out in and near Otago Harbour, and should be read in conjunction with other reports from the same area (Graham, 1938, pp. 399-419; 1939, pp. 421-436). The subject in its entirety embraces a study of the spawning habits, the location of the spawning grounds, the date of spawning, the identification of eggs and larvae, the rate of growth and the relation between growth rate and seasonal resources. Surface nettings provide valuable means of collecting eggs of such fish as red cod, hake, tarakihi and ling, a valuable short cut as compared with the locating and capture of spawning fishes of species with demersal eggs.

#### **Mustelus antarcticus** Guenther. Smooth-hound.

Females examined in February contained embryos 2 inches long; in March, 3 inches; in May, 4 inches; in July, 5½ inches; in October, 7 to 9 inches. The number of young to each litter varied from 5 to 23. However, during this same October some females were found to contain embryos in a very early stage of development, from the formation of the germ ring to a length of 3 mm. The young are born in November and December, average length 10½ inches.

Young dogfish school separately from their parents, and fish of the same size continue to associate together as they grow, with the result that individuals of any given school are of relatively uniform size and consist of either large males or females, or of immature fish of both sexes.

#### **Lamna nasus** (Bonnaterre). Porbeagle shark.

A specimen caught near Otago Heads on May 23, 1933, had three well-developed young within a few weeks of birth, weighing 9½, 9 and 7½ lb., a total of 26 lb.

#### **Squalus fernandinus** Molina. Spined dogfish.

Females are more numerous than males. It appears that while the females are gravid the sexes become segregated, though frequenting the same locality; in March, for example, hauls of males only have been taken in the trawl, and other hauls of females only. The young are born alive during the summer (November to February). Gravid females as small as 24 inches in length have been taken. Small round knobs on the dorsal spines of the embryos protect the parental organs from laceration. In Blueskin Bay, one of the localities most favoured by adults, young specimens evidently born only a short time may be taken in the cod end of the trawl net, so that perhaps parturition,

though usually taking place at greater depths, can occur in these shallow waters. In this bay the young linger for about a year before moving into the Harbour or into deeper water. Possibly birth can occur even in the Harbour, for a female taken at Quarry Point in mid-January, 1930, contained five young in one uterus, all apparently ready for extrusion, with the yolk sac completely absorbed, whereas the other uterus was enlarged and empty as if a half-litter had been born already. The lengths of the five were  $10\frac{1}{2}$ ,  $11\frac{1}{2}$ ,  $11\frac{1}{2}$ ,  $11\frac{1}{2}$ ,  $11\frac{1}{2}$  inches. Another specimen taken in May, 1932, had seven embryos only half as long ( $4$  to  $5\frac{1}{2}$  inches) in one uterus, the other uterus being apparently healthy yet sterile.

**Raja nasuta** Mueller and Henle. Skate.

Capsules containing well-developed eggs, apparently ready for extrusion were found in October, January and February, suggesting that spawning occurs in the autumn. Two fish two feet in length had developing eggs not yet in capsules. Of numerous capsules taken in the trawl in Blueskin Bay, only one was fertile, and this failed to hatch in an observation tank.

**Callorhynchus milii** Bory. Elephant-fish. (Plate 41, figs. a, b).

In November, eggs one inch in diameter were found in the ovaries almost ready to pass down the oviduct to be enclosed in capsules; in March, capsules the colour of tow and ready for extrusion were taken from fish caught in Blueskin Bay. On April 19 a capsule was picked up on the beach at Seacliff with an immature embryo  $2\frac{1}{2}$  inches long; weight, 10 grams (plate 41, fig. b); yolk sac  $1\frac{1}{2}$  inches long and empty. On May 28, a capsule was washed ashore at Brighton containing an almost fully developed fish with distended yolk sac (plate 41, fig. a); weight 320 grams. Empty capsules were often dredged and trawled in Blueskin Bay, no doubt one of the breeding grounds of elephant-fish. The egg cases washed ashore are rarely more than 10 inches long, while those taken from fish in January and from the cod-end of the trawl in February measured  $16\frac{1}{2}$  inches; colour yellowish-green and almost covered with tow-like fibre. The pointed ends of trawled capsules were discoloured and macerated, suggesting that they had been thrust into the soft ocean floor by the female.

**Sardinia neopilcharda** Steindacher. Pilchard.

Well developed ovaries were found in numerous specimens from Beaconsfield Bay on December 15, 1931, perhaps exceptionally late. Lengths of fish were as follows: October,  $2\frac{1}{2}$  inches (Cape Saunders, stomach of red cod); February, 3 inches (Beaconsfield Bay); March,  $2\frac{1}{2}$  inches (Beaconsfield Bay; evidently a later spawning); March and April,  $2\frac{1}{2}$ – $2\frac{3}{4}$  inches (Lower Portobello; sexually immature); autumn mature open-sea fish 4–5 inches.

**Glupea antipodum** (Hector). Sprat.

One ripe female taken from stomach of whiptail caught at The Rock in 50 fathoms off Cape Saunders, May 16, 1931; weight of ovaries, 17 grams; diameter of egg, 0.05 mm. Numerous specimens from the same fish and also bream, same locality, showed the process of spawning had been recently completed. It seems evident that The Rock is in the vicinity of a spawning ground of this fish.

**Hippocampus abdominalis** Lesson. Seahorse.

A female and three males were kept in a tank during 1931. Ordinarily during the day they remained attached to the outlet pipe or weed, but on December 12 they were unusually active, the males passing and re-passing the female as closely as if trying to touch her or approach as near as their feeble movements would allow. When the female, who was evidently ready to transfer her eggs, was temporarily removed from the aquarium, a number of eggs were secured by gentle pressure on the pouch. They were oval, 2.3 mm. by 1.4 mm., semi-transparent, brick red, granulated, and had a distinct perivitelline space. They were sufficiently plastic to conform in shape to the surface on which they rested. They sank in water and had no oil globule.

The female showed marked preference for one of the three males, which swam almost erect, jerking their heads forwards as they approached. When the two unfavoured ones approached, the female turned away as far as possible, or if they were too attentive, released her hold on the weed and swam off, if possible to her favourite. The removal of the latter from the tank did not restore the others to favour; he was therefore replaced, and the other two removed. Even then, after many approaches by the male and after various stationary and swimming postures by the female, there was considerable difficulty in securing the requisite nuptial embrace. All the movements were slow, though somewhat less deliberate than normal in this sluggish fish. The required grasp was at length secured while the female had her tail resting on the floor of the tank, and in an instant the oviduct, which appeared enlarged, was inserted into or at least against the pouch of the male and some of the eggs were transferred. This inverted coitus lasted a few seconds, after which the pair separated, the female making violent efforts to free herself, and, when successful, attaching herself to a stalk of weed; the male performed contortive movements on the floor of the tank, stretching and twisting as if to arrange the eggs in place. At intervals of five minutes, at least 13 embraces occurred; in the intervals the flaps of the male pouch were observed to be dilatable and apparently under muscular control. After the last embrace, when the male pouch had become distended and the female compressed, the male attached himself to the outlet pipe of the tank and remained there apparently without feeding for many hours, after which he began to feed and relished a supply of amphipods (*Caprellina longicollis*) placed in the tank. The oviduct of the female receded considerably during the next few hours; the outer part is an intromittant organ under at least temporary control. It was not determined whether fertilisation occurs during the process of egg-transference.

Males are ovigerous in summer, as verified several times by dissection. The eggs hatch in January and February, 30 days after transference, the young being fully developed and able to swim, averaging 17 mm. in length; up to 182 are "born" from a single parent. The latter process was observed several times; it occupied about an hour, the young emerging rapidly in succession with occasional interruptions, during which the male rubbed the pouch

on the weed as if to press the remaining ones forward. Prolonged observations did not support the assertion that in this genus the young are able to enter and leave the brood sac at will. For the first few hours the young swam parallel and close to the surface of the water, and were attracted by light, but later sank to any depth.

**Hemirhamphus intermedius** Cantor. Garfish. (Plate 42, figs. 1-11).

Specimens nine inches in length and weighing only four ounces were found to have ripe roes.

The first attempt to hatch artificially-fertilised eggs, from parents taken with the seine net in Company's Bay, November 23, 1931, failed after a fortnight, through the deposition of rust from the iron water-supply pipes. A month later, another lot progressed satisfactorily after the substitution of rubber hose and the exercise of meticulous care in removing sediment and dead eggs. Hatching boxes with an adequate circulation of water proved more successful than glass jars. The relatively large eggs, diameter 2.6 mm. (plate 42, fig. 1), are demersal, and in the tanks became attached to weed by the filaments, or collected into balls of several dozen, which had to be shaken apart to free them from sediment. Eggs were noticed on weed in the stomachs of mullet caught in the same haul as the parent garfish.

Stages in the development are shown in pl. 42, figs. 1-11; the period of incubation ranges from 36 to 45 days. In the one-day fish the dorsal fin commences above the vent, which is at the posterior two-thirds of the length; the dorsal, caudal, anal and ventral fins are continuous. The characteristic silvery colour of the adult has been assumed, but the caudal fin is not yet forked and the lower jaw not yet elongated (figs. 9-11). This fish (fig. 9) shows the lower jaw less than 0.1 mm. in length; in a two-day-old fish (fig. 10) the jaw measured 0.15 mm., and after four days (fig. 11) 0.25 mm. The only larva taken, after repeated attempts, in a tow net measured 26 mm., the lower jaw 4 mm. in length.

**Coelorrhynchus australis** (Richardson). Javelin-fish.

One specimen, ovaries almost fully developed, August 26, 1931; eggs 37,000, diameter 0.35 mm.

**Macruronus novae-zelandiae** (Hector). Whiptail.

One specimen, ovaries almost ripe in May.

**Merluccius gayi** (Guichenot). Hake.

A specimen taken at North Reef in 200 fathoms (July 25, 1933) contained about 1,450,000 eggs; weight of roes 275 grams; eggs bright orange, diameter 0.06 mm.

**Physiculus bachus** (Bloch and Schneider). Red cod.

The roes are ripe during July and August, at which times the fish do not bite freely. The sexually mature adults leave the harbour and other inshore grounds at this time, and for a short period may be taken in 20-23 fathoms. The presumption that they spawn in deeper water, beyond the range of the trawlers, is supported by the catching of ten fish with ripe roes at the North Reef in 80 fathoms (September 16, 1931); these fish, which were in good condition, averaged 29 inches in length and 7½ lb. in weight; the roes varied from 7½ to 8½ fluid ounces, and as shown in the following table, the eggs varied considerably in number and in size.

Number of eggs.	Average diam. of eggs.	Diameter of oil globules.	
		Maximum.	Minimum.
4,900,000	0.35 mm.	0.08 mm.	0.02 mm.
3,350,000	0.40 mm.	0.10 mm.	0.05 mm.
2,600,000	0.45 mm.	0.13 mm.	0.07 mm.

Assuming that red cod spawn in September, the juveniles caught in Blueskin Bay and the Harbour in March, from four to six inches long, are about six months old, and those taken in August and September in the same localities, measuring about nine inches, are one year old. Specimens 12 to 15 inches long, common off the northern side of Goat Island in the Harbour in late summer and early autumn, are presumably two years old. Sexually mature fish measure at least 20 inches and are probably four years old.

**Pseudophycis breviusculus** Richardson. Bastard red cod.

A ripe female was taken among blue cod at Taieri Mouth (January 10, 1933), at least four months later than the end of the spawning season of red cod. The eggs were estimated at 2,260,000; diameter 0.5 mm., oil globule 0.15 mm.; eggs larger than red cod, globules larger but less numerous. Recently spent fish were secured in February, 1933.

**Zeus faber** Linnaeus. John Dory.

One specimen with mature ovaries taken in August, 1933, eggs about 37,000; diameter 1.8 mm., white, almost transparent; oil globule conspicuous, lemon coloured, diameter 0.32 mm. Specimen in poor condition with numerous crustacean parasites on the gills.

**Cyttus australis** Richardson. Boarfish.

Ovaries not fully mature in September, probably ripe about October.

**Cyttus novae-zelandiae** (Arthur). Silver dory.

Eggs well developed in August; diameter 0.75 to 1.0 mm.

**Peltorhamphus novae-zelandiae** Guenther. Common sole.

Maturation is evidently a long process; the ovaries begin to enlarge in the small fish, and immature eggs were found in a 6½ inch specimen; on the other hand, the smallest specimen with mature eggs measured 9½ inches. No such sign of maturity was found in specimens from the Harbour, yet juveniles ranging from 1½ to 6 inches are common there throughout the year.

**Agonostomus forsteri** (Cuvier and Val.). Yellow-eyed mullet.

The ovaries are well developed in December. Juveniles 1½ inches long are common close inshore in the Harbour, where they are preyed on by 9-inch barracouta.

**Hyperoglyphe porosa** (Richardson). Bream.

Roes commence to enlarge in September and are almost ripe in December.

**Polyprion americanus** (Bloch and Schn.). Bass-groper.

The roes are ripe in July; eggs 11,600,000, diameter 0.22 mm., oil globule 0.05 mm.

**Polyprion oxygeneios** (Bloch and Schn.). Groper.

Although the early stages remain unknown, no specimens less than one pound in weight having been seen, the movements of the parents are known. In May and June, when the roes mature, there is an outward movement into deeper water such as the North Reef to spawn. The migration is well defined, and is recognised by fishermen, who follow the fish as they retreat from the coast. Spawning occurs in July and August, at which season the females preponderate in the catches in the ratio of 3:1. A discovery of ripe roes late in December was evidently quite exceptional. In October and November the return movement commences, the fish, especially the females, being in their lowest condition. During July and August the bottom jaws, the lips, the nose and the undersurface of the shoulders of mature fish are scratched or scarred. It may be that this results from a habit of nosing or scratching away sand, gravel or rocks in order to spawn (Tenison-Wood, 1883, p. 103) or from fighting with one another at spawning time.

The prevailing wanton methods of fishing, including over-fishing, have intensified exploitation during the spawning season, resulting in a serious decline in the numbers and sizes of the fish, and action is called for with a view to gaining control over the situation. At best, recovery from the damage already done will probably be slow. An indication of the destructive effect of the present lack of control was obtained in 1932 and 1933 by estimating the number of ripe female groper marketed from the North Reef. Many of the ripe roes weighed 9lb., some even 10½lb. Roes containing a million eggs per pound weight were seen, and even half this number would imply that 300,000 million eggs were sold on the market during each year. Such a loss, appalling in its magnitude, even in a marine environment, cannot be viewed with equanimity.

**Trachurus novae-zelandiae** Richardson. Horse-mackerel.

Ripe males and females were examined on the market (February 22, 1933). Length of female 20 inches, weight 2¾lb.; diameter of eggs 0.6 mm., yolk 0.4 mm., no oil globule; total eggs 440,000.

**Arripis trutta** (Forster). Kahawai.

Roes well developed in February, probably maturing in March or April.

**Dactylopagrus macropterus** (Forster). Tarakihi.

Specimens with ripe roes were taken at the North Reef in 100 fathoms (December 8, 1932); the ovaries of a 23-inch fish (cleaned weight 7lb) weighed slightly over four ounces and contained about 3,300,000 eggs; colour orange, diameter 0.2 mm.

**Latris lineata** (Forster). Trumpeter.

The roes are ripe in July, and the fish are in optimum condition in May and June, poor in July after spawning. Ripes roes from 25lb. fish in July, 1933, weighed 4 ounces and contained about 12,000,000 eggs. The winter spawning occurs in water well below the 23-fathom line to which the fish migrate in summer.

**Coridodax pullus** (Forster). Greenbone.

Repeated attempts at artificial fertilisation, between November 9, 1931, and January, 1932, at the station failed because no ripe males could be secured. A 19-inch female had 67,000 eggs; diameter 0.23 mm., granular and pink in colour. There is no ready explanation of this apparent protogyny, unless the males move into deeper water when fully mature, the females following.

**Crapatalus novae-zelandiae** Guenther.

A specimen examined in June was almost ripe with 18,000 eggs; diameter 0.47 mm.

**Parapercis colias** (Forster). Blue cod.

The departure of gravid fish in June and the return of spent fish in September indicate the normal limits of the spawning season. In 1933 gravid females were nevertheless found in mid-December, perhaps after an ineffective visit to the spawning grounds. The roes of a 2½ lb. specimen of these late-maturing fish contained about a million eggs; diameter 1.01 mm.

**Katheostoma giganteum** Haast. Flathead.

Ova well developed in February, almost mature in March. Those of a specimen weighing 10½ lb. contributed 2 lb. to this weight, and contained some 800,000 eggs.

**Notothenia macrocephala** Guenther. Maori Chief.

Eggs ripe in November; diameter 0.25 mm.

**Thyrsites atun** (Euphrasen). Barracouta.

The late autumn period of April-May-June, during which the fish reach their best condition, is the period of the development of the roes; towards the end of July they are nearly mature and the fish disappear from the surface. The interpretation of this disappearance is a matter for constant debate among fishermen; it is not known whether there is a minor downward movement, a movement to the inshore bottom, or an offshore migration by the main body at least. Some certainly remain in comparatively shallow water, for mature specimens are occasionally taken in winter on the line, e.g. from The Rock at Cape Saunders and in 80-100 fathoms on groper beds 12 miles offshore. The fact that only a few are taken at these depths after the July migration does not disprove the presence there of large numbers, especially as those taken are never found to have been feeding freely; in October and November the stomachs are completely empty, or at most contain a few benthic fishes and crabs; it is a perplexing detail that these include an admixture of inshore benthic animals.

Until it is more reliably known whether the main body is in the neighbourhood of this 100-fathom zone in winter, it cannot be claimed that the spawning grounds are known. However, there can be no doubt that the disappearance in July is a spawning migration, as sufficiently shown by the prior maturation of the gonads, and by the reappearance of the fish in numbers at the surface in October, when they are found to have spawned and to have become very thin and hungry.

The data as to the movements of young fish are still more fragmentary, especially since the conspicuous inward migrations in summer and autumn, when extensive shoals enter the Harbour, are performed by juveniles of three sizes (4, 9 and 18 inches), so sharply marked off from one another as to indicate three ages at distances of a season. These have evidently come from the same bottoms as the adults that are caught during the spawning season, for on the supposed spawning grounds young specimens 4-7 inches long are found in the stomachs of several species of fish, including red and blue cod, kingfish and sea perch.

***Acanthoclinus quadridactylus*** (Bloch and Schn.). Rockfish.  
(Plate 41, fig. c; plate 42, fig. 12.)

Eggs were found at Seal Point, Otago, in October, 1931, but the following observations were made at Auckland in 1926. In July and August the ova were observed to be nearly mature; in October a female was found under a stone in an intertidal cavity containing *Zostera* leaves, and was evidently in the act of spawning. The tail was quietly moving, and the fish appeared unperturbed by the temporary removal of the stone. A fortnight later the cavity was found to be occupied by a male, guarding a ball of eggs; the sides had been built up so that neither fish nor eggs could escape, nor could enemies enter. The water was not sufficient to cover more than half the bulk of the eggs or the fish. From October to December several other such cases of self-imprisoned males in charge of a ball of eggs were found. In marked contrast to their usual behaviour the fish were unperturbed by the removal of the eggs, or even by the handling of the fish itself. The tail quietly lashed the water, ceasing when the eggs were lifted and recommencing when they were replaced. Eggs were found in different stages, and in one case they had already hatched, the larvae swimming in the pool still accompanied by an adult male. It appears that one or the other sex, probably the female, chooses a suitable spot and scoops out a shallow hole without closing the entrance; the female then deposits the eggs and departs; the male then enters, closes the entrance, fertilises the eggs, and remains on guard until after they are hatched. The heavy egg cluster (plate 41) was held together by threads, which also entangled *Zostera* leaves, sponge and other extraneous matter, and formed a mass sufficiently compact to be picked up and suspended from a piece of wire. Shortly before hatching (pl. 42, fig. 12), the embryo is large and plump, occupying the whole circumference of the egg, and with the circulation well established. The posterior portion of the body is free from yolk and the embryo moves freely within the egg. The pigmentation characteristic of the adult is already in evidence. Diameter of egg 1-3 mm., oil globule 0.12 mm.

***Tripterygion varium*** (Forster). Cockabully. (Plates 43, 44.)

A fish was noticed to spend much time in and around a gastropod shell (*Lunella smaragdus*), and on the following day appeared even more attentive, spending up to 20 minutes at a time in the shell; after a period inside, with tail or head or neither visible in the aperture, it would partly emerge and perform regular movements with the fins and tail. It was later verified that eggs had been deposited within.

A fortnight later the female was seen chasing a smaller fish, evidently a male, along the walls of the pond and among weed, until they began to encircle the shell in narrowing circles and finally came to rest on it. After about a minute the male made a brief inspection of the interior, returned and rested on the shell with the female, then entered the shell again and did not return. The female thereupon withdrew and, after feeding ravenously on pieces of fish thrown into the water, departed and was not seen again. The male stayed in the shell, sometimes with the head protruding, and was not observed to leave the shell or to feed. After another fortnight the shell was raised with a net, the male remaining placidly within, and observations were continued in a smaller aquarium. The fish was seen to dart into the shell (plate 43, fig. a), turn round, and partially emerge with the head protruding (plate 43, fig. b); then violent movements from side to side were seen, with rapid movements of the pectoral and ventral fins; then the fish emerged further, and the tail could be seen lashing the water inside the shell. Diameter of egg 0.9 to 1 mm.

**Genypterus blacodes** (Bloch and Schn.). Ling.

Well-developed roes occur in August with very numerous eggs; ripe in late September, weight 116 grams, eggs approximately 1,200,000; diameter 2.1 mm., oil globule 0.4 mm.

**Helicolenus percoides** Richardson. Sea perch. (Plates 45, 46.)

The vivipary already recorded by Anderton (1921, p. 88) adds especial interest to the development and breeding of this species. The two ovaries (pl. 45), varying in size from 70 x 38 mm. to 60 x 25 mm., are contiguous with the ducts coalescing anteriorly; the progressive formation of abundant oil globules tinges the originally colourless ovary until it reaches a yellowish-grey hue, overlain ventrally by dark grey or blackish pigments in the peritoneum. The highly vascular ovarian membrane is characterised by transverse ridges. The ovarian follicles (pl. 46, fig. 25) are stalked, terminal or secondary or tertiary or further subdivisions of a complex branching system, richly vascular, and provided with a granulated periphery inside the smooth enveloping capsule. Some eggs lie free in the semi-fluid ovarian matrix, including some which are larger than any of the stalked ones; but detachment does not depend on the attainment of maturity, as shown by the great range of stages among the stalked eggs.

This range is such as to suggest that parturition is intermittent; it can at least occur in two phases, for in a single ovary there may be found not only abundant examples of all the stages represented in a continuous series (pl. 46, figs. 26-34), but also, after a marked gap without further intermediate stages, the full-term larvae ready for extrusion (fig. 35). In another case one ovary contained 80,000 eggs ranging in size from 0.25 to 0.75 mm., and the other had a similar number of larvae ready for extrusion. The finding of this latter case in February, 1930, and of another similar one in June, seemingly indicates an extension by six months of the spawning season as recorded by Anderton (1921, p. 88), who found such specimens in September and December. Unless some of these cases are rare anomalies, there can be at most no more than a brief non-spawning season in July and August.

The process of spawning was witnessed in February, 1930. After a restless period contrasting with the usual sluggishness, a captive seaperch turned partly on one side and for about half an hour extruded at ten-minute intervals jelly-like material which soon floated to the surface; the total mass occupied 155 cc. and contained some 88,000 larvae (pl. 46, figs. 35, 36, 37), wriggling in the jelly-like matrix, which dissolved in about 20 minutes. Next day (pl. 46, fig. 39), the young fish were swimming freely, mostly at an angle of 45° in the water; the jaws were as yet imperfectly formed, and it was not until the fourth day (pl. 46, fig. 40), after the disappearance of the yolk sac, that plankton was observed to be eaten.

**Gongiopodus leucopocilus** (Richardson). Pigfish.

Roes were observed in June, there being over 50,000 eggs per fish. In spite of the constant use of the garfish bunt during seine netting operations in the Harbour, no pigfish smaller than 4½ inches were taken. In captivity a fish of that size increased one inch in length in five months (November to April), probably slower than in its natural habitat.

**Neophrynichthys latus** Hutton. Toadfish. (Plate 47, fig. a.)

Spawning occurs in July and August; eggs, 13,000; diameter 2.6 mm. In the observation tanks eggs were deposited on a piece of rough rock, to which they adhered (see figure), or were scattered about in small heaps of several hundreds (they remained unfertilised, as no males were available).

**Chelidonichthys kumu** (Lesson and Garnot). Red gurnard.

Gurnard usually spawn in March. A 14½-inch fish (marketed December 6, 1933) had fully mature roes with 180,000 eggs; diameter 1.7 mm.; copper-coloured oil globules, 1.3 mm.; sometimes coalescent after spawning. About 80 per cent. of some hundreds of fish examined were females. The smallest ripe female measured 11½ inches.

**Diplocrepis puniceus** (Richardson). Sucker-fish. (Plate 46, figs. 41-45; plate 47, fig. b.)

The secondary sexual differences are striking. Apart from the much smaller size, males are distinguished by the brilliant colours; the females are bright rose on the upper surface and yellowish below, whereas the males are olive-green, brown or grey with darker lines, tinged with red, yellowish or pale lilac above and black laterally; others are red with pale and dark longitudinal stripes. There is an endless variety in the forms and arrangement of the colour patches, some males being striped, others being spotted, others blotched and barred. The colours of the males are even brighter in the breeding season, when they are more frequently seen. In other seasons they appear outnumbered by the females in the ratio of 5:1, but on account of their small size and presumed preference for deeper water it is doubtful whether there is any genuine disparity in the relative numbers.

Eggs were seen from early September to the end of November, deposited in irregular masses under rocks (plate 47), stones and shells, almost invariably on smooth surfaces. They are usually found a little above low-water mark, sometimes higher up, in pools which



FIGS. a, b.—*Callorhynchus milii* Bory. Embryos.

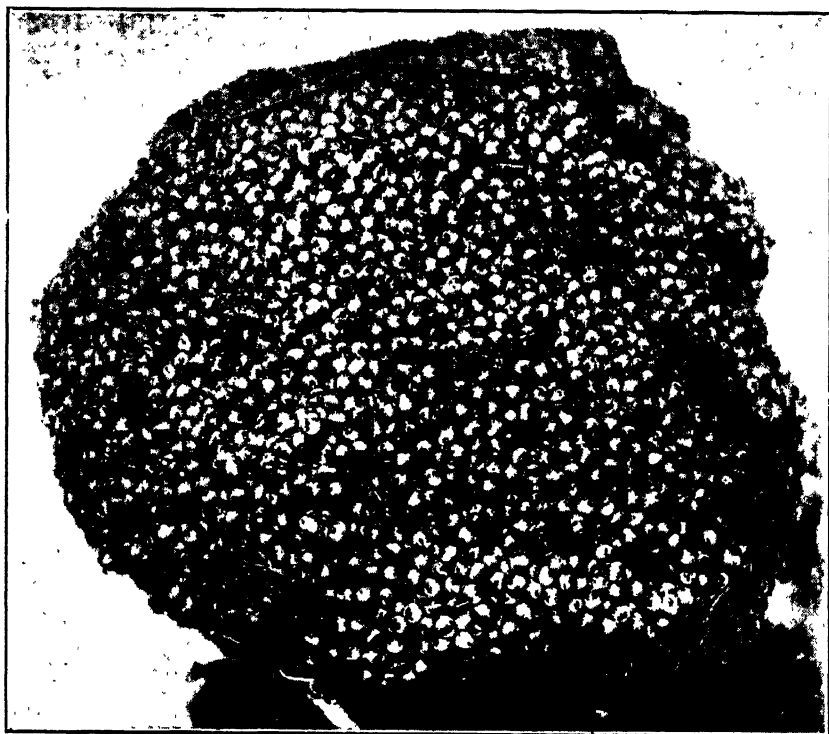
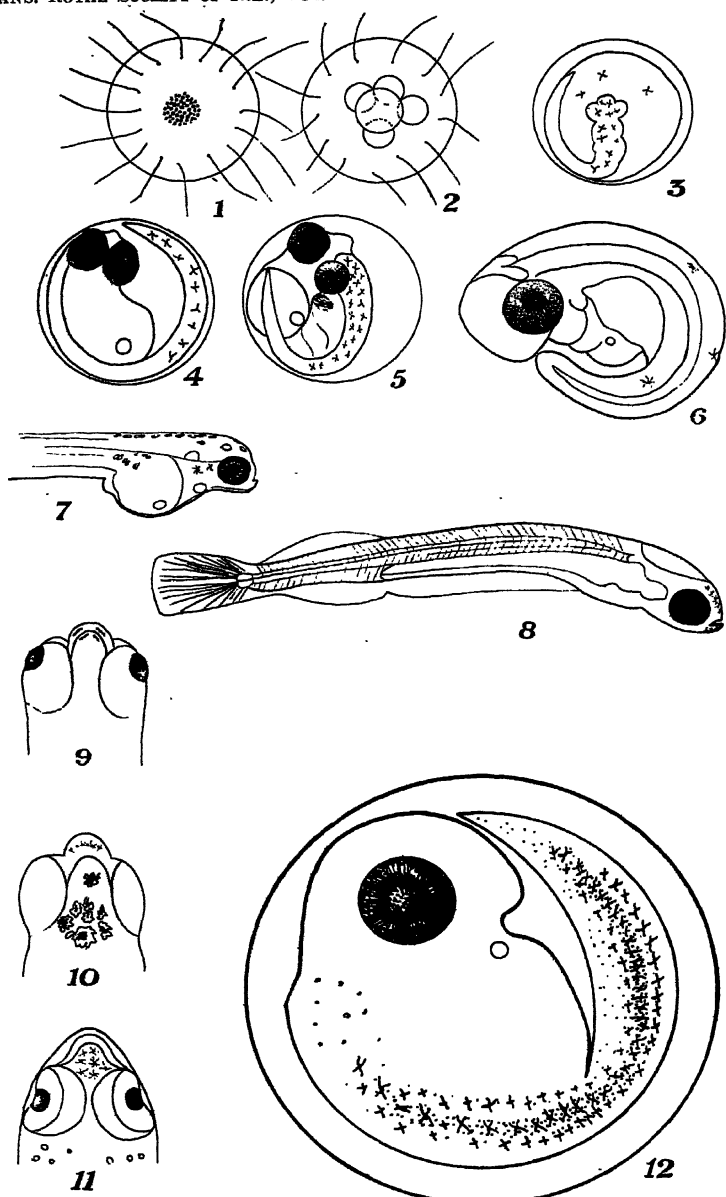


FIG. c.—*Acanthoclinus quadridactylus* (Bloch and Schn.). Egg cluster.





*Hemirhamphus intermedius* Cantor.

FIG. 1.—Unfertilised egg, diameter 2.6 mm., adhesive filaments 1.7 mm. Oil globules numerous, central (as shown) or scattered. FIG. 2.—Egg 26 hours after fertilisation; blastoderm 5-celled. FIG. 3.—Egg 23 days after fertilisation; embryo well formed, with pigment spots; less than periphery of egg; no movement or circulation observed (unusual). FIG. 4.—Egg 26 days after fertilisation; embryo forming complete loop, moving freely within membrane; pigmentation conspicuous posteriorly, but embryo relatively transparent. FIG. 5.—After 30 days; pigmentation further advanced; yolk sac and oil globule still recognisable. FIG. 6.—Embryo ready to hatch. FIG. 7.—Newly-hatched larva; length 7 mm., yolk sac still large, oil globule still present; head not deflected, dorsally pigmented. FIG. 8.—One-day-old larva; length 8 mm.; tail fin with rays raised, myotomes distinct, oil globule and yolk sac reduced; pigmentation especially prominent above head. FIGS. 9-11.—Dorsal views of head, ages 1, 2, and 4 days respectively, showing commencement of elongation of lower jaw (lengths 0.1 mm. or less, 0.1 mm. and 0.25 mm. respectively). FIG. 12.—Unhatched embryo taken from egg cluster, pl. 41, fig. c—*Acanthoclinus quadridactylus* (Bloch and Schn.).





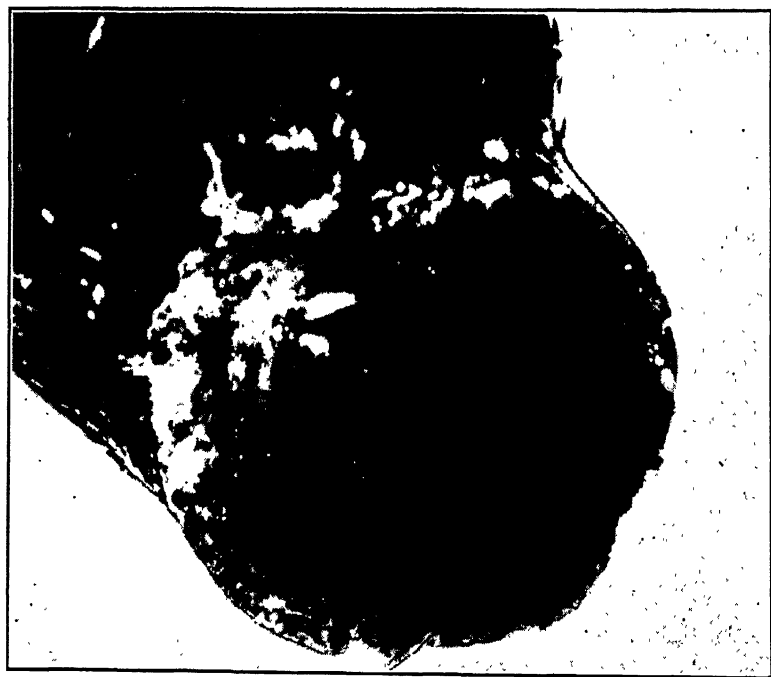


FIG. a.—Male entering shell.



*Tripterygion varium* (Forster).

FIG. b.—Male on guard in shell.



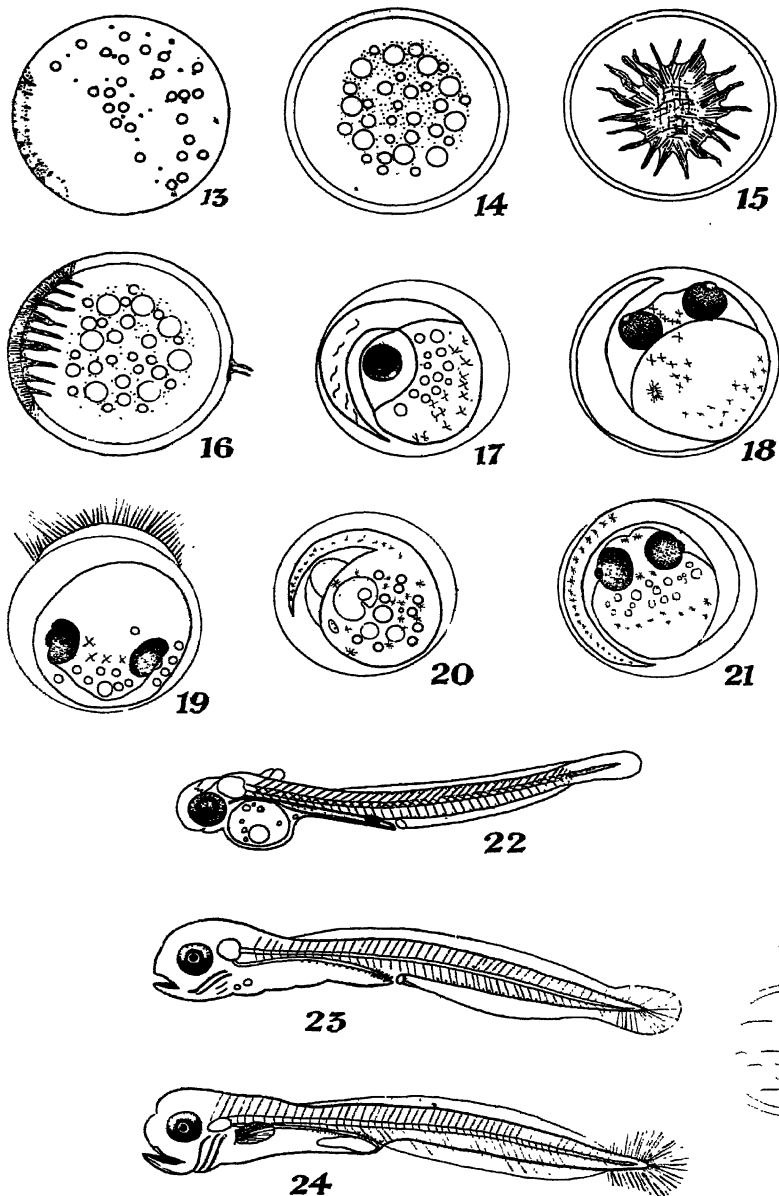
*Tripterygion varium* (Forster).

FIG. 13.—Ripe egg, 0.9 to 1 mm.; scattered oil globules and yolk; internal ventral filaments. FIG. 14.—Segmenting egg; embryonic shield surrounding oil globules; embryonic axis defined. FIG. 15.—Ventral attachment filaments. FIG. 16.—Central oil globules; micropyle. FIG. 17.—Embryo exceeding a complete circle; pigmentation slight. FIG. 18.—Do., showing dorsal pigmentation. FIG. 19.—Do., with adhesive filaments. FIG. 20.—Do., chromatophores and oil globules. FIG. 21.—Embryo ready to hatch; pigmentation well marked, eyes green, yolk sac slightly reduced; the larva turns over about 20 times per hour. FIG. 22.—Newly hatched larva; length 3.3 mm., yolk sac incompletely absorbed and hindering movements; oil globules 7, diameters 0.05–0.17 mm.; green dots behind yolk sac, red jagged patch above eyes, black stellate chromatophores near vent. numerous dorsal and ventral dots from vent to tail. FIG. 23.—Four-day larva; length 5.0 mm.; 2 small oil globules, yolk sac nearly absorbed. FIG. 24.—Six-day larva; length 6.5 mm.; mouth, branchiostegals, and pectorals well developed; head blunt (cf. adult); air bladder conspicuous. Larva





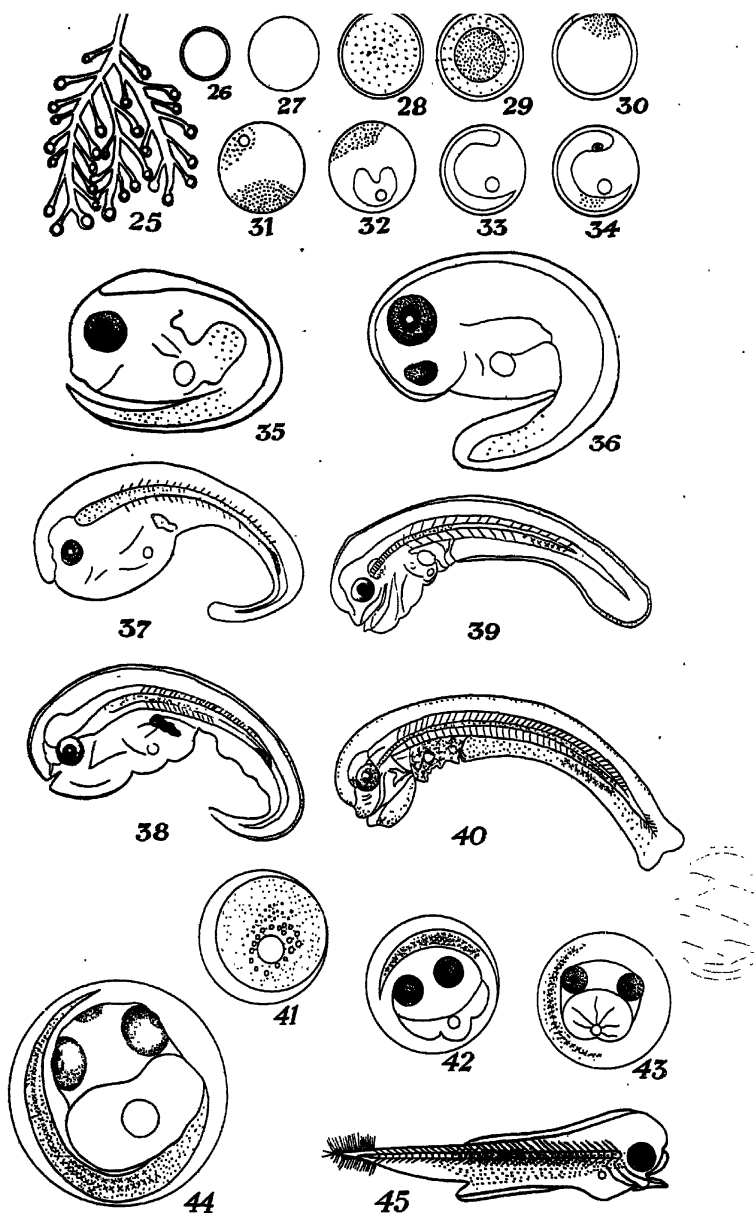
*Helicolenus percoides* Richardson. Mature ovaries, showing contiguous lobes, anterior fusion of ducts, pigmentation of capsule, artificial release of eggs.











*Helicolenus percoides* Richardson.

FIG. 25.—Follicles on secondary and tertiary axes. FIG. 26.—Homogeneous doubly-contoured egg. FIG. 27.—Opaque coagulation in follicle. FIG. 28.—Unsegmented egg showing micropyle, perivitelline space, scattered protoplasmic granulations. FIG. 29.—Blastoderm cleavage, periblastic mottled numerous and conspicuous in life. FIG. 30.—Earliest stage, incipient blastodisc in lateral view, showing polar concentration of protoplasm; perivitelline space distinct. FIG. 31.—First oil globule at late stage of blastodisc formation. FIG. 32.—Embryonic rudiments at pole opposite the blastodisc. FIG. 33.—Early embryo, occupying  $\frac{1}{2}$  of circumference. FIG. 34.—Minute chromatophores towards tail (typical, but not invariable), eyes densely pigmented. FIG. 35.—Larva at time of hatching; uncoiled length 2.2 mm. FIG. 36.—Newly-hatched larva in oblique, dorsal view; body plump, yolk sac protuberant, jaws unformed, posterior dorsal and ventral edges normally with marked pigmentation. FIG. 37.—Larva, half an hour after birth, uncoiling, yolk sac reduced; groove in position of future jaws. FIG. 38.—Four-hour larva; feebly swimming, length 2.8 mm. FIG. 39.—One-day larva; length 3.3 mm.; yolk sac almost absorbed; jaws, branchiostegals, and vent recognisable; yellow pigmentation from vent to eye; a patch of black stellate chromatophores above vent, another towards the tail; two small oil globules in front of original globule. FIG. 40.—Four-day larva, length 5 mm., pre-anal granulations especially concentrated on mid-dorsal line; black chromatophores massive posteriorly; myotomes well formed; jaws functional, larva feeding on plankton.

*Diptocrepis puniceus* (Richardson).

FIG. 41.—Newly-deposited egg; diameter 1.0-1.7 mm.; oil globule 0.42-0.47 mm. FIGS. 42-43.—Do., more advanced. FIG. 44.—Two-day embryo; active, almost encircling periphery; body reddish; tip of snout and back and especially mid-dorsal line with black stellate chromatophores; oil globule 0.5 mm. FIG. 45.—Newly-hatched larva; length 5 mm., oil globule 0.15 mm.; body compressed, everywhere closely covered with black and brown chromatophores; yolk sac almost absorbed;



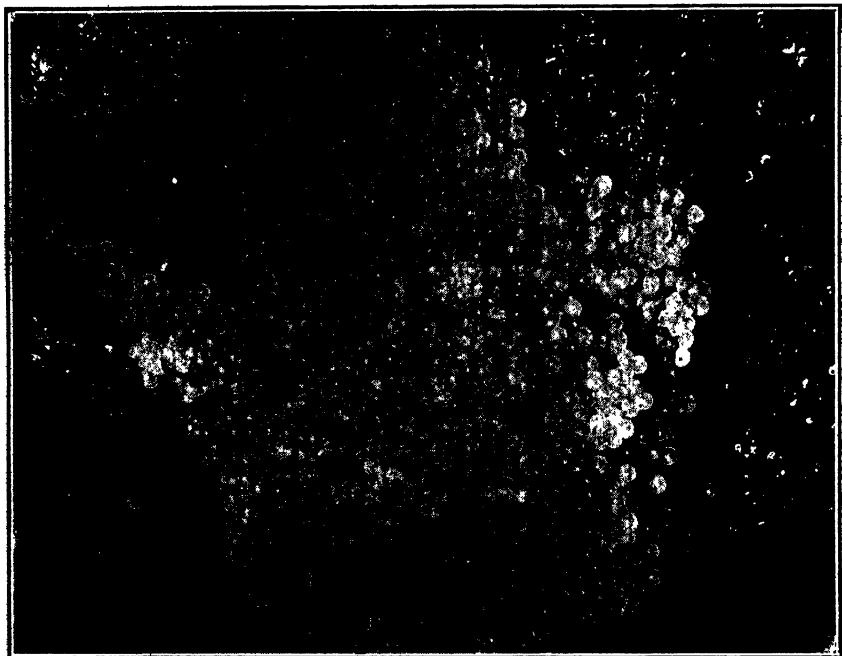


FIG. a.—*Neophrynichthys latus* Hutton. Egg-cluster on rock in observation tank.

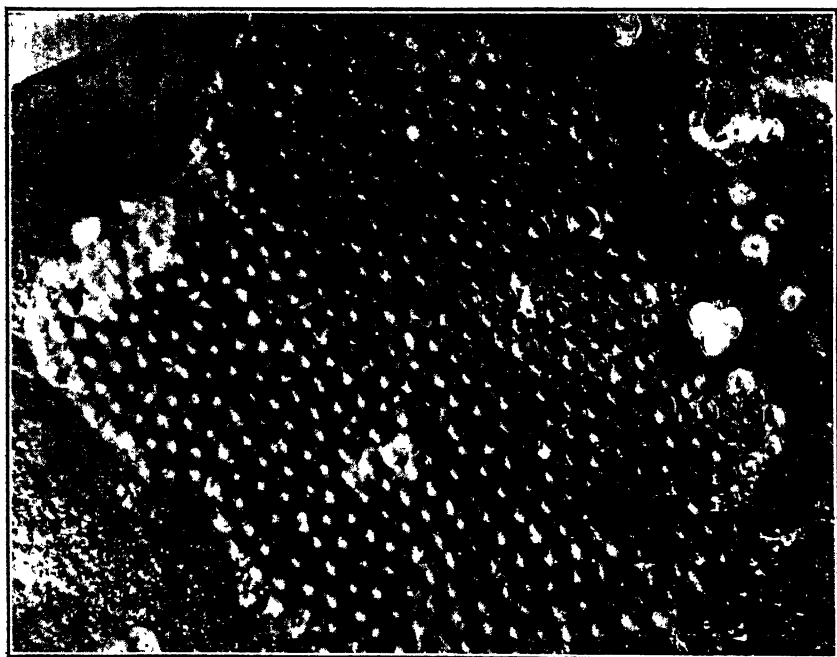


FIG. b.—*Diplocrepis puniceus* (Richardson). Egg-cluster on rock.



are not drained at low tide; perhaps also they occur below low-tide level. In the tanks, spawning occurred twice in empty *Halotis* shells and once on glass. Much movement occurred during oviposition; after a few minutes of quietness the fish would extrude an egg, then wriggle from side to side as if attaching it.

Parental care was observed on the part of the male. A female interrupted during spawning would endeavour to escape, and in any case the eggs were forsaken when laid; but the male, after having fertilised and assumed charge of the eggs, guarded them assiduously with little concern for his own safety. Male guardians studied in the tanks fasted and became thin and exhausted. They moved constantly back and forth across the mass of eggs, perhaps to keep them free from foreign matter by the fanning action of the tail. In the two cases studied the male was ultimately eaten by a female, presumably his mate. It is uncertain whether this cannibalism was a perversion induced by the captive condition; but, in any case, to swallow, head first, a wide-bodied fish, half as long as the consumer, proved a difficult task. The male was alive, in one case, an hour after capture, the head being out of sight, but the tail protruding from the mouth of the female. After ultimately swallowing the male, the female was much distended and next morning was found dead. Captivity, whether on account of confined space, stillness of the water or high salinity, certainly interferes with oviposition. Fish distended with eggs or even captured in the act of spawning were unable, with the exception of some from sheltered localities, to spawn in the tanks, even though they appeared to be trying to do so. They nevertheless became less distended, and dissection showed that the ova were disintegrating; on the other hand, none of the many sucker-fish kept in the tanks over long periods died unless by violence. The  $3\frac{1}{2}$ -inch fish produced 16,000 eggs, at first soft, but soon hardening. In the tanks about 1 to 2 per cent. were not fertilised. As development proceeded the pink colour was replaced by straw, pale green, and finally purple with progressive intensity. One lot of eggs simultaneously exhibited the whole sequence of colour phases, suggesting progressive fertilisation. Normally the larva hatches after 21 days. Diameter of egg 1.6 to 1.7 mm., oil globule 0.42 to 0.47 mm.

#### CONCLUSION.

It is clear from the above preliminary and scattered notes that the local fishes, although limited in number of species, exhibit reproductive phenomena as complex and varied as those in any comparable area.

#### ACKNOWLEDGMENTS.

The writer is indebted to Dr. E. W. Bennett for helpful criticism and assistance during the compilation of this paper; to Mr. S. Broadley, for much and varied help in the hatching of fish and in the laboratory; to many fishermen, retailers, auctioneers and others who assisted by saving fish with ripe roes; to Miss Thelma Kent, A.R.P.S., for photograph of plate 49 and prints of line drawings.

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**The Glaucous *Hebe* of the Inland Patea.  
*Veronica colensoi*, *V. hillii*, and *V. darwiniana*.**

By N. L. ELDER, M.A., F.R.G.S.

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June 28, 1939; published separately, December, 1939.]

PRELIMINARY.

THE position of the glaucous North Island Hebes variously referred to, under these species, was outlined by Cockayne and Allan in 1926 ("The Present Status of the N.Z. Species of *Hebe*," *Trans. N.Z. Inst.*, vol. 57, pp. 26-28). They pointed out the unsatisfactory state of our knowledge concerning all the forms, and considered that these should be studied afresh.

An investigation of the area in which the group occurs was begun in 1930 and has been continued to the present. Though it is apparent from the accompanying map that the area involved (roughly a 50 km. square) has only been partially covered, it should be noted that a large part of the central area consists of the tussock plateau of the Inland Patea, which does not afford a suitable habitat. Attention has been concentrated on the river valleys to east and west and the Kaimanawa, Kaweka and Ruahine ranges which bound the area to north and south, and these have been as thoroughly searched as time and the type of country have permitted.

The available evidence points to the existence of three distinguishable jordanons of one species, obscured by considerable epharmonic variation and (in part of the area) by hybridism between jordanons. The type specimens and published descriptions of the different forms given specific rank (*Veronica colensoi*, *V. hillii* and *V. darwiniana*) cannot unfortunately be correlated with any of these jordanons, and must be referred rather to epharmonic variation or hybridism with other species of *Hebe*.

OCCURRENCE AND HABITAT.

The glaucous-leaved *Hebe* referred to *V. colensoi* in Cheeseman's *Manual* (1925) occurs in isolated colonies of limited extent, mostly on the cliffs of the river valleys surrounding the plateau of the Inland Patea, the Mangamaire, Rangitikei, Taruarau and Ngaruroro. An outlying colony occurs in the Makahu to the east of the Kaweka Range, and Colenso in his account of the crossing of the Ruahine Range mentions one specimen on a ridge above the Maropea Stream, but the exact location is not known at the present day. It is usually found in an association of a much wider distribution with *Angelica rosaefolia* and a rupestral *Hebe* resembling a much-stunted *H. angustifolia*, but it is found, much depauperated, in manuka on road cuttings

west of the Taruarau and at four thousand feet in the Southern Kaweka in a sub-alpine association, on the divide between the Ngaruroro and Tutaekuri Rivers.

It is subject to very heavy infestation by a white scale in the Rangitikei-Erewhon area (also observed in the Makahu at the eastern extremity of its range) and in cultivation is very susceptible to attacks of the fungus of *Peronospora* sp. under damp conditions. The root system is not developed near the surface, as, for example, that of *H. laevis*, and it stands drought well.

#### IDENTIFICATION.

The species in general is easily identified from its open habit, leaves bunched at the tips and glaucous on both surfaces (not green above as stated in the *Manual*) and racemes forming a close head when in flower (fig. 3). The leaf shape also is most commonly oblong-obovate or elliptic, certain changes taking place with age, so that the leaves tend to become broader and less glaucous from the tip of a twig downwards (fig. 2).

The main drawbacks to successful identification have been the wide range of forms, particularly in leaf shape, amount of marginal incision, the occurrence of branching of racemes, and to a certain extent the degree of glaucescence, though this does not appear a difficulty in the field.

#### EPHARMONY.

The group has been studied by a combination of field observations with cultivation, from which it appears that considerable epharmonic variation is present, which accounts for the presence or absence of branched racemes, the small-leaved and most of the narrow-leaved forms. The branching of the bottom pair or two pairs of racemes is general in cultivation. (In only one case, where from other considerations hybridism was suspected, have simple racemes persisted in cultivation.) In well-grown plants half to two-thirds of all flowering stems show branching. The upper racemes persistently remain single, and not infrequently a terminal spike is developed forming a panicle (fig. 3). This has also been observed in the field in two instances.

The leaves in cultivation increase in size (approximately 10% in dimensions) but preserve their characteristic shape except forms with linear-oblong, slightly-incised leaves, which prove to be epharmones of a jordanon with elliptic much-incised leaves which is described below.

The first leaves are green and toothed, the toothing persisting into the second year of growth as incisions in glaucous leaves, though the adult plant may bear entire leaves, and in rare cases where these incisions persist the cause seems more likely to be epharmonic than due to hybridisation with a jordanon bearing incisions.

#### JORDANONS.

Eliminating these variations, three jordanons can be identified on leaf shape and the presence of marginal incisions (fig. 1). The basis is partly geographical as indicated by the following table:—

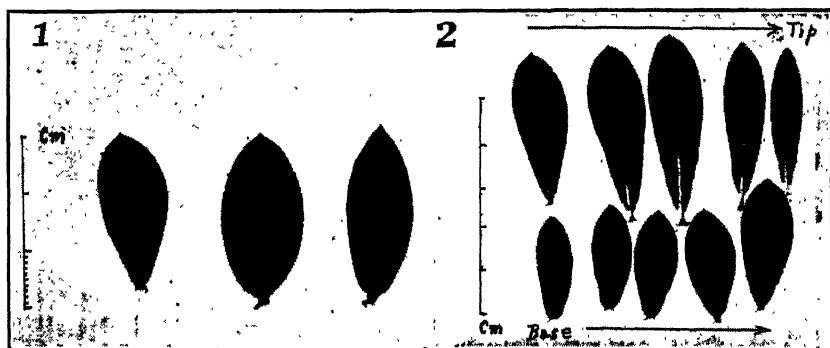


FIG. 1.—*Hebe colensoi*. Leaf forms of Jordanons. 1—Taruarau. 2—Kuripaponga. 3—Rangitikei.

FIG. 2.—Changes in Leaf Form from base to tip of Shoot. Jordanon 1 (Cultigen).

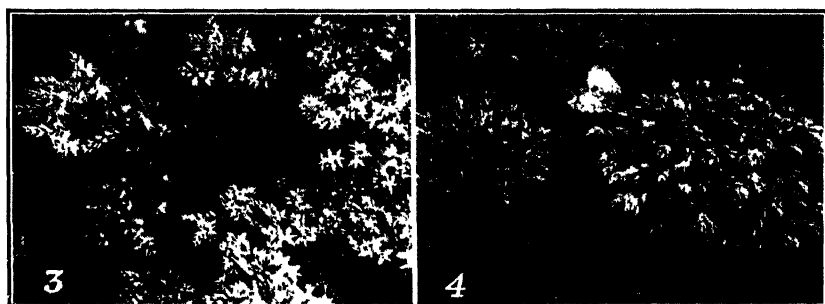
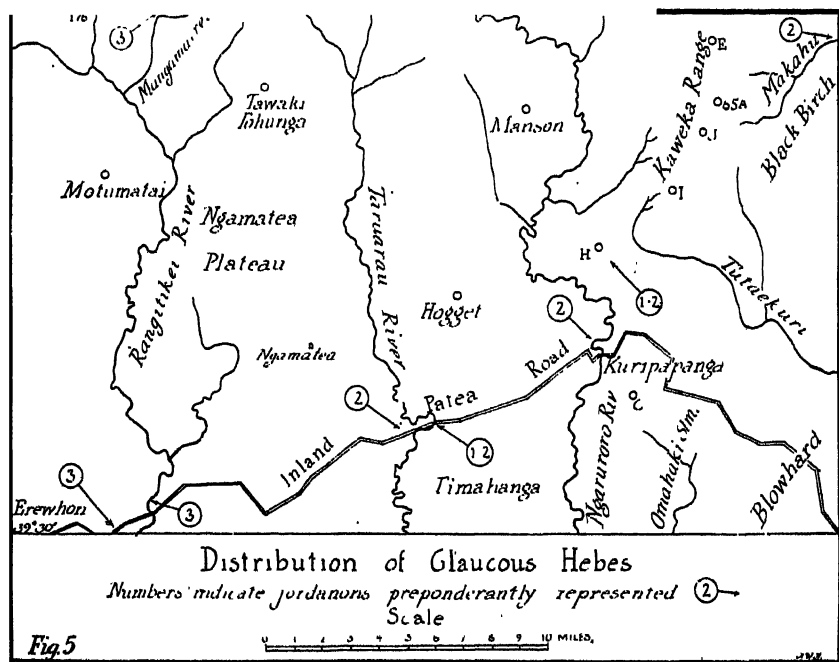


FIG. 3.—Jordanon 1 showing racemes and terminal panicle.

FIG. 4.—Jordanon 2. Jordanon 3. In cultivation, showing typical drooping habit of the latter.







*Distribution of Glaucous Hebes (percentages).*

		Margin Entire.		Margin Incised.	
		Leaf obovate. Jordanon 1.	Leaf elliptic.	1-10 pr. general. Jordanon 2.	0-3 pr. occasional.
Eastern.	Kuripapanga ..	0	0	78	22
	Makahu .. ..	0	14	50 + 17	19
	S. Kaweka ..	35	9	35	21
	Taruarau ..	51	15	13	21
	Eastern total ..	31	12	37	21
Western.			Jordanon 3.		
	Rangitikei and Mangamaire	3	93		4
	Western total ..	3	93		4

These figures can only be taken as rough approximations for the colonies of the eastern area, though the totals for the eastern and western areas represent large and comparable numbers.

The first column represents a jordanon with obovate entire leaves most strongly represented at the Taruarau bridge, and probably occurring all through the eastern area. It comes true from seed and agrees with the Kew specimen of *V. hillii* Col. It does not appear to be present in the western area, the figure in that column covering variations in leaf form in specimens otherwise recognisable as a western jordanon.

Column 2 covers a well-marked jordanon, of the Western area, distinguished by the larger size of fully-developed plants and drooping branch tips (fig. 4). The leaf has a characteristic shape—Cheeseman's "oblong-lanceolate" perhaps describes it better than "elliptic." It does not occur in the eastern area; the figures in that column certainly refer to hybrids between another Eastern jordanon and that of column 1.

Column 3 represents the jordanon, preponderant at Kuripapanga and the Makahu and present throughout the Eastern area. It is distinguished by much-incised elliptical leaves. Its seedlings are noticeably slower than those of the other jordanons to assume the glaucous colour of the adult form and epharmonic variation is more marked, the extreme form having a linear-oblong leaf, only slightly incised.

The lesser figure against the Makahu colony represents a group with strongly serrated rather than incised leaves, whose affinities are not obvious. The colony is a comparatively small one, outside the main area of distribution, and having only recently been located, breeding experiments have not yet had time to give any results.

The fourth column does not lend itself to ready analysis, but consists partly of exposed epharmones of the third jordanon, and almost certainly a number of cases of occasional juvenile toothling persisting in adult forms of both the first and second jordanons.

A large proportion of the fourth column together with column 2, however, must be referred in the eastern area to the existence of hybrids between jordanons one and three. Except in the Makahu a fair range of forms in leaf shape and the development of incisions occur in each colony, and, though jordanon one has not been collected at Kuripapanga, forms closely approaching it have been.

Hybridization with other species is suspected in one example at the Taruarau, but cultivation from seed has given no definite proof of this.

In the Dominion Museum Petrie's No. 6 from the Upper Rangitikei ford, "identified at Kew in 1891 as *V. colensoi*," appears to be a hybrid, its blackness in drying suggesting *Hebe buxifolia* as a possible parent.

#### HISTORICAL.

In dealing with the taxonomic history of the species I am greatly indebted to Dr. H. H. Allan, who has given me very full information, particularly of the type specimens of *V. colensoi*, *V. hillii*, and *V. darwiniana*, examined by him at Kew.

*V. colensoi* Hook. f., in *Handbook N.Z. Flora*, 1864, p. 209.

Colenso sent to Hooker f. specimens (4062 and 4265) "from a high stony ridge above the River Taruarau between Hawke's Bay and Taupo. *V. glauca* W.C.," and this material was used by Hooker (together with South Island material, since separated by Cheeseman) in founding *V. colensoi*.

These specimens are at Kew, and from a tracing of the leaf outline this appears to be an exposed epharmone of jordanon one which is well represented at Taruarau bridge.

*V. hillii* Col., in *Trans. N.Z. Inst.*, vol 28 (1896), p. 606.

This was founded on specimens collected by Hill at Kuripapanga in 1894. He notes "in drying, the leaves lose much of their dark-green colour above and become glaucescent," and Cheeseman apparently uses this information in his description of *V. colensoi* (*Manual*, 2), citing *V. hillii* as a synonym. Apart from leaf colour (all forms are definitely glaucous on both surfaces) the Kew type is a luxuriant form of jordanon one.

*V. darwiniana* Col., in *Trans. N.Z. Inst.*, vol. 25 (1893), p. 332.

This was collected by Colenso "in hills in the interior, Hawke's Bay." He describes the leaves as "glaucous-green, eight to nine lines long by two and a half to three lines broad," and, in comparing it with *V. colensoi* Hook., adds "leaves smaller, sub-concave and of another form."

The leaf-outline of the Kew specimen, apparently the only one in existence, suggests the exposed epharmone of jordanon two, in which case some trace of incised margins would be expected.

[The description in the *Manual* (2) appears to refer to the South Island *V. glaucophylla*, included there with it, but fairly certainly specifically distinct.]

DESCRIPTION.

*Jordanon One.*

As in the *Manual*, but leaves  $\pm 2.4$  cm. long by  $\pm 1$  cm. wide (considerably reduced in exposed situations), oblong-obovate, sub-acute, slightly keeled, glaucous on both surfaces. Lowest pair or two pairs of racemes (except in exposed situations) tripartitely branched, upper simple.

Locality: Isolated colonies Taruarau and Ngaruroro Rivers on rock faces, 1800 ft. to 3000 ft. Fell-field, S. Kaweka, 4500 ft. Flowering October to January.

*Jordanon Two.*

As for One, but leaves  $\pm 3$  cm. long by  $\pm 1.1$  wide, elliptic, with 8-10 pr. marginal incisions (in exposed situations, leaves linear-oblong  $\pm 1.9$  by  $\pm 0.6$  cm., 0-2 pr. marginal incisions).

Locality: With One, and crossing with it. Also on Makahu Stream (Puketitiri).

*Jordanon Three.*

As for One, but a larger plant  $\pm 70$  cm., branches spreading or prostrate, frequently drooping at tips. Leaves  $\pm 2.5$  cm. by  $\pm 0.9$  cm., elliptic-lanceolate, entire.

Locality: Isolated colonies in Rangitikei watershed; on rock faces Mangamaire River; Rangitikei River at ford above present bridge and on road to the west at Blackhill. 2000 to 3000 ft.

SUMMARY..

(1) The glaucous-leaved Hebes discussed belong to one species, for which the earliest name, *Hebe colensoi* (Hook. f.) Ckn., is adopted.

(2) Three jordanons are described and their relations with *V. colensoi*, *V. hillii* and *V. darwiniana* are examined. These names, however, are based on such imperfect material and the jordanons are so close that varietal names are not proposed.

## Note on the Tetrasporic Form of *Gigartina alveata*.

By VICTOR W. LINDAUER.

[Read before Hawke's Bay Branch, May, 1939; received by Editor, May 29, 1939; published separately, December, 1939.]

SETCHELL and GARDNER (1933, p. 282), speaking of the sub-genus *Mastocarpus*, note that although cystocarpic and antheridial plants of the Algae belonging to that sub-genus are found in abundance and are so generally distributed, it is a remarkable fact that not a single tetrasporic plant has been recorded in spite of the careful search that has been made for them. The authors even put forward the suggestion that this type of reproduction may be absent in the sub-genus. Again, the same authors (1934, p. 132), referring to *Mastocarpus*, state: "Soris tetrasporangiis nondum visis, probabiliter defectis."

Owing to the desirability of making further observations of the New Zealand plants belonging to this group, and to the fact that some question has always existed as to the exact position of the *Alveatae* in relation to *Gigartina* and *Chondrus*, which might be settled to some extent were tetrasporic material available, the writer has used every endeavour to isolate the tetrasporic plant of *Gigartina alveata* (Turn.) J. Ag. in order to provide the material necessary for the researches of Dr. W. A. Setchell, of California, and Mr. R. M. Laing, of New Zealand.

Although diligent search for some years proved unsuccessful, the writer was rewarded in March, 1937, when the first material was discovered at Long Beach, Russell, Bay of Islands. More specimens were found in the same locality in April and May of that year, while in July a few plants were collected at Takou Bay between the Bay of Islands and Whangaroa, and later, in December, at Ahipara, near the Ninety Mile Beach. No specimens appeared in 1938, but in February and March of this year (1939) rich material was again present at Long Beach.

*Description:* In general appearance the tetrasporic plants of *G. alveata* resemble the cystocarpic very closely, the branching being strictly dichotomous, the frond palmate, and the tips flabellate. The latter, however, have a tendency to stand erect, although the tip finally incurves, more or less. Juvenile and sterile fronds scarcely differ from those of cystocarpic plants. Tufts of tetrasporic plants have, however, a tentacular appearance at the tips, while in texture the thallus is softer and less rigid to the feel, so that in collecting they may be readily distinguished by that characteristic alone.

*The tetrasporic sori:* Sporangia first make their appearance in one or more small, oval, raised pustules of a dark sienna colour on the convex side of the frond below the upper forks, generally about the fifth dichotomy. The sori gradually extend upwards and downwards (as the plant grows and adds to its dichotomies), becoming largish patches well raised above the surface of the frond. After the liberation of the spores scars are left in place of the sori, but new

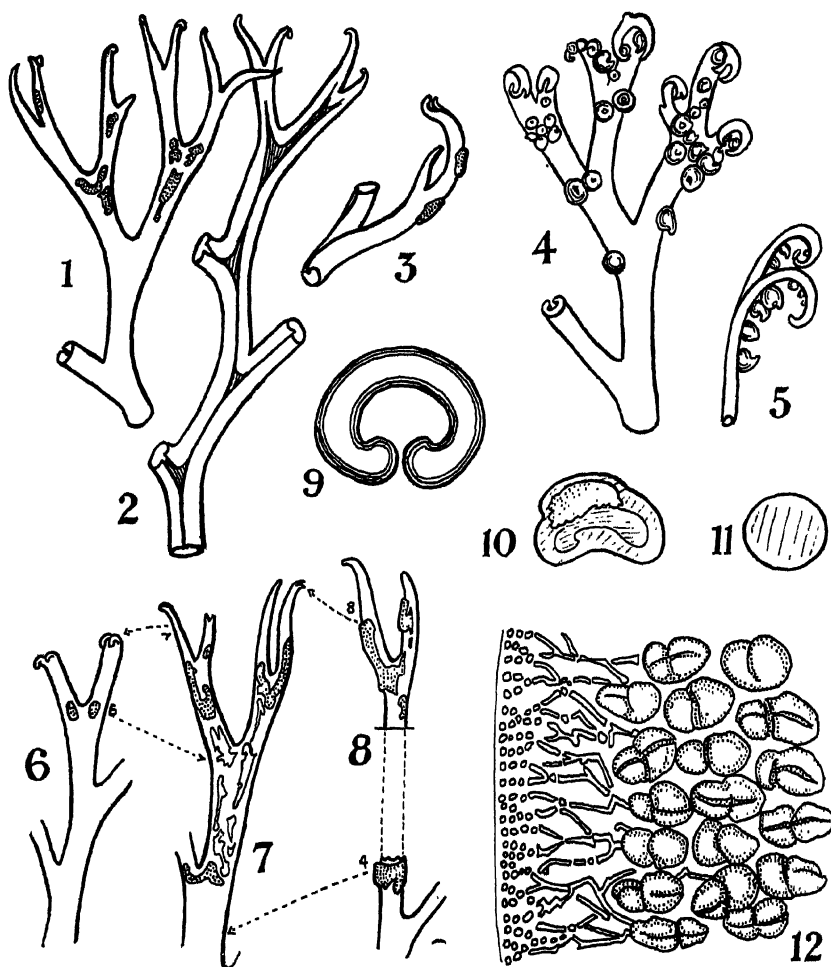
*Gigartina alveata* (Turn.) J. Ag.

FIG. 1.—Habit sketch of fragment of tetrasporic plant, convex side, showing sori.  $\times 2$ .  
 FIG. 2.—Sketch of channelled side.  $\times 2$ . FIG. 3.—Side view of tip of frond bearing sori.  $\times 2$ . FIG. 4.—Habit sketch of cystocarpic plant for comparison with FIG. 1.  $\times 2$ . FIG. 5.—Tip of cystocarpic frond, side view, for comparison with FIG. 3.  $\times 2$ .  
 FIG. 6-8.—Sketches illustrating the progressive extension of the sori upwards and downwards. (FIG. 6.—The first sori appear in this specimen at the base of the sixth dichotomy. FIG. 7.—Frond has increased in length, sori have spread, leaving spent portion between. FIG. 8.—Sori have extended to the ultimate dichotomy above and to the fourth below, where severance has taken place, leaving new sorus band at 4.)  
 FIG. 9.—Cross section of frond at first dichotomy.  $\times 10$ . FIG. 10.—Cross section of tetrasporic thallus at 7th dichotomy.  $\times 10$ . FIG. 11.—Cross section of basal part of frond.  $\times 10$ . FIG. 12.—Cross section showing cruciate tetraspores densely aggregated.  $\times 120$ .



sori appear extending to the very tip of the frond. The "spent" portion of the frond has, in the meantime, begun to disintegrate and has acquired a greenish-yellow colour, and here severance takes place at the inferior end, leaving a sorus band at the tip of the standing portion. It will be noticed that the tetrasporangial sori are present only on the under, convex surface of the frond and that they occupy the same relative position as do the cystocarps in the female plant.

As mentioned by Hooker (1867, p. 699) *G. alveata* is a gregarious plant. It occurs on certain clean rocks below the rock-oyster (*Saxostrea glomerata*) and the barnacle (*Chamaesipho columna*) belts on sandy beaches in exposed situations, but never in association with *Xiphophora* or *Carpophyllum* and not always with other *Gigartina*. As far as present observations indicate tetrasporic *G. alveata* prefers situations facing the open sea at low-water mark, neap tides, just above the *Pachymenia himantophora*, the *G. macrocarpa* and *G. cranwellae* belt, and frequently associated with a small mussel (*Mytilus canaliculus*). Rarely are both cystocarpic and tetrasporic plants found growing together apparently from the same vegetative base; usually the plants are isolated, each growing in a small individual tuft.

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**TRANSACTIONS**  
**AND**  
**PROCEEDINGS**  
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**VOL. 69**  
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## Catalogue of Aurora Australis Displays, 1931-1938.

By M. GEDDES, M.A., F.R.A.S.,

Director, Carter Observatory.

[*Read before the Wellington Branch, June 28, 1939; received by the Editor, June 29, 1939; issued separately, March, 1940.*]

### SUMMARY.

A COMPLETE list of all the aurorae observed in New Zealand from 1931 to 1938 (inclusive) is given, together with data which it is thought might be useful for anyone wishing to use the material for correlation work. Three hundred and forty-eight displays are discussed.

Auroral observations have been carried out in New Zealand since 1931, and the present catalogue lists all displays observed since that date. Until about the middle of 1933 the organisation of the observers was incomplete, so that the number of displays observed before this date is probably much less than the number actually visible. During the whole period the work was carried out by the Aurorae and Zodiacal Light Section of the New Zealand Astronomical Society, although recently it has been taken over by the newly-established Carter Observatory.

The arrangement of the catalogue has been made with a view to presenting the matter in a form suitable for correlation studies with other phenomena. Unfortunately it is not possible to include all the data in such a table, but it is hoped that the most significant features of each display have been indicated. In many cases the data given have been determined from a very large number of reports, over a hundred in the case of the larger aurorae.

Times in all cases are U.T. Columns 1 and 2 give the reference number of the display and the date. Columns 3 and 4 show the times of first and last observation of the display. It should be realised that these are not the times at which the aurora began and ended; in some cases this may be so, but there is no way of determining whether the aurora was in existence before the observer saw it or whether it continued after he had completed his observations.

Column 5 gives the time of maximum activity, i.e., the time at which the aurora appeared to reach a peak in the general cycle of activity. In the case of a large display there may be a number of such maxima in the course of the night, all of which are listed in the table. Where one maximum was much stronger than the others this fact has been indicated by the insertion of the letter "p" after the time.

Occasionally the activity reaches a definite minimum between two successive maxima. Where such times can be determined they are included in column 6.

Column 7 contains the main auroral types shown by the display. The abbreviations used and an explanation of the types are shown in the supplementary Table 2. Where the types varied for the different maxima they are shown separately.

The scale of intensity used in column 8 is given in the supplementary Table 3. Intensities are given for each maximum. In some cases no entry has been made in columns 7 and 8, owing to the fact that it has proved impossible to determine the type and intensity. Where this is due to cloud hindrance an indication is given in the remarks column.

In cases where the times given are only approximately correct this has been indicated by an asterisk.

TABLE I.—AURORAE OBSERVED IN NEW ZEALAND, 1931-38.

Ref. No.	Date. U.T.	U.T. of First Obs. h. m.	U.T. of Last Obs. h. m.	U.T. of Maxima. h. m.	U.T. of Minima. h. m.	Main Types.	Intensity.	Remarks.
1931								
1	Jun.					G	1	Cloud
2	Oct. 29	10 30	11 30			RA	3	
1932								
3	Jan. 1	12 45	12 45			R	2	
4	Mar. 4	10 00	10 00			R	3	
5	Apr. 3	07 35	09 15			RA	3	
6	Jun. 10	11 00	11 30			G	1	
7	Aug. 3	06 00	10 00				2	
8		28 08 00	11 30			RA	3	
9	Sep. 21	07 30	09 30			—	—	Cloud
10		23 06 10	11 00			RA	3	
11	Oct. 3	07 30	13 35			RA	3	
1933								
12	Jan. 17	15 00*	15 00			R	2	
13		18 10 00	12 00			G	1	
14		19 12 30	13 30			R	2	Note 1
15		28 08 45	09 00			—	—	Note 1
16	Feb. 16	11 30	12 00			R	2	Note 1
17		25 06 00*	06 00			G	1	
18	Mar. 19	10 30	12 15			RA	2	
19		23 12 05	12 50			G	1	
20		27 07 30	09 20			RA	2	
21	May 18	07 00	08 03	07 40		RA	2	
22		21 06 15	07 00			HA	1	
23		30 10 35	11 10			G	1	
24	Jun. 20	06 30	11 15			G	1	
25	Jul. 11	14 00	14 00			RA	3	
26		23 12 00	15 30	14 00		RA	2	
27		24 09 15	13 15	11 00		RA	2	
28		26 10 00	12 30			G	1	
29	Aug. 13	07 45	09 00			G	1	
30		17 08 15	09 45			G	1	
31	Sep. 8	08 30	09 30			—	—	Cloud
32		9 07 00	15 15	08 22 15 00		D, F, PS D, F	4 4	
33		14 07 35	08 25			R	2	
34		15 07 30	12 40	12 25		RA	2	
35	Oct. 7	09 50	13 30			R	3	
36		13 12 30	13 05			R	1	
37		29 10 00	10 00			—	—	
38	Nov. 25	09 00	09 40			R	2	
1934								
39	Feb. 5	08 45	09 00			DS	1	
40	Apr. 9	07 30	14 45			R, F, PS	3-4	Cloud
41		10 11 00	11 00			G	1	
42	Jun. 3	07 30	11 00			G	1	
43		15 12 45	14 00			G	1	
44	Jul. 3	11 30	13 00			R	2	

Ref. No.	Date. U.T.	U.T. of First Obs. h. m.	U.T. of Last Obs. h. m.	U.T. of Maxima. h. m.	U.T. of Minima. h. m.	Main Types.	Intensity.	Remarks.
45	9	07 00	07 00			—	2	Cloud
46	24	10 10	10 10			R	2	
47	29	10 30	11 45			G	1	
48	30	06 15	14 00	09 00		HA, RA	4	Note 3
49	Aug. 1	08 00	08 30			G	1	
50	3	12 00	12 30			R	1	
51	12	10 00	11 00			G	1	
52	20	08 00	08 00			HA	—	
53	22	07 30	08 30			HA	2	
54	Oct. 26	09 15	10 30			G	1	
55	Nov. 5	09 30	09 30			G	1	
56	7	09 30	11 30	11 10		—	2	
57	10	11 00	11 00			G	1	
58	11	09 00	09 00			G	1	
59	Dec. 11	10 00	10 00			G	1	
1935								
60	Jan. 10	09 45	09 45			—	—	
61	Feb. 3	12 20	13 25	12 38		RA	2	
62	Mar. 17	08 00	14 30			R	2	
63	18	08 00	09 15			R	2	
64	Apr. 5	11 30	11 30			R	2	
65	9	08 15	14 45	08 45*		RA	3	
66	10					G	1	Cloud
67	11	10 25	12 45	12 20		D	3	
68	12					G	1	Cloud
69	25	08 30	09 30			G	1	Cloud
70	May 11	11 00	11 00			R	2	
71	13	11 30	11 30			DS	1	
72	30	08 00	11 30			G	1	
73	Jun. 7	09 30	01 30			G	1	
74	8	10 30	10 30			G	1	
75	9	11 38	13 00	12 30		RA	2	
76	19	14 00	14 00			—	2	Cloud
77	26	15 00	15 00			—	—	Cloud
78	Jul. 8	11 00	14 00			RA	2	
79	14	10 30	10 30			—	2	Cloud
80	22	08 45	10 30			R	2	
81	23	09 00	09 00			R	2	
82	24	13 00	13 30			R	2	Cloud
83	25	07 30	13 20			RA	3	P.
84	28	11 00	14 00			DS	1	
85	29	08 30	08 30			HA	1	
86	Aug. 1	12 30	13 30			RA	2	
87	Sep. 11	13 00	13 45			RA	2	
88	17	12 15	12 15			G	1	
89	18	10 30	13 50			RA	2	P.
90	19	09 15	11 30			—	—	Cloud
91	20	13 00	13 00			G	1	
92	23	09 30	11 45			RA	2	
93	24	11 30	11 30			G	1	
94	25	08 00	14 00			R	2	Cloud
95	30	07 00	11 42			RA	2	
96	Sep. 1	11 30	11 30			—	—	Cloud
97	Oct. 16	09 20	09 30			G	1	
98	17	11 30	11 30			G	1	
99	20	10 30	12 30			RA	3	
100	21	13 15	13 15			R	—	Cloud
101	24	07 30	08 30			R	2	
102	Nov. 3	09 55	10 25			G	1	
103	14	09 55	10 25			G	1	
104	15	09 55	10 25			G	1	
105	20	10 00	10 00			G	1	

Ref. No.	Date. U.T.	U.T. of First Obs. h. m.	U.T. of Last Obs. h. m.	U.T. of Maxima. h. m.	U.T. of Minima. h. m.	Main Types.	Intensity.	Remarks.
106	21	08 40	10 25			HA	2	
107	Dec. 24	11 30	12 30			—	2	Cloud
	1936							
108	Jan. 18	11 00	11 40			RA	3	Red
109	19	10 30	10 30			G	1	
110	25	11 45	13 45			DS	1	
111	Feb. 2					G	1	
112	14	09 15	09 45			RA	3	
113	17	09 00	10 00			G	1	
114	19	12 30	13 15			—	—	Cloud
115	22	09 30	11 30			G	1	
116	24	09 00	09 00			G	1	
117	Mar. 10	08 30	11 30			RA	3	
118	17	12 30	12 30			—	—	Cloud
119	18					G	1	
120	21	09 30	11 30			R	2	
121	22					RA	2	
122	23	11 30	12 45			R	2	
123	25	09 30	09 30			R	2	
124	Apr. 17	11 00	12 55	12 05		RA	1-2	
125	18	09 40	10 00			G	1	Cloud
126	26	15 00	16 45			DS	1	
127	27	16 00	17 00			DS	1	
128	May 12	07 45	08 40			HA	1-2	
129	17	15 00	16 00			DS	1	
130	26	09 00	12 30	11 45		RA	2	
				12 15		RA	2	
131	29	13 30	14 00			G	1	
132	Jun. 1	11 14	11 30	11 35		RA	3	Red
133	2	12 10	12 30			R	3	
134	9	07 30	07 30			G	1	
135	16	09 30	12 30	11 15		RA	2	
136	19	05 30	15 30	07 00p 08 00		RA	3-4	
						RA	3	
137	20	07 30	08 30			—	—	Cloud
138	24		09 00			R	1	
139	Jul. 4	08 00	07 00			R	3	
140	15	08 30	08 30			G	1	
141	18	08 00	11 45			G	1	
142	19	10 30	10 30			G	1	
143	26	05 30	08 00			—	2-3	
144	Aug. 9	10 00	11 15			2	2	Cloud
145	10	10 45	12 30			—	—	Cloud
146	12	08 00	08 30			G	1	
147	16	07 00	09 00			R	2-3	
148	19	07 20	07 50			G	1	
149	27	08 45	10 17			R	2	
150	28					R	2	
151	Sep. 8	12 00	12 00			G	1	Cloud
152	19	08 15	08 45			DS	2	Red
153	Oct. 6	08 25	09 05			G	1	
154	8	07 50	12 00			—	—	
155	9	12 00	13 00			G	1	
156	10	08 00	13 00	08 15*		R	2	
157	12	11 30	11 30			G	1	
158	31	11 45	12 45	12 20		RA, D	3	Red
159	Nov. 11	10 30	13 45	11 42		R	2	P
160	12	08 30	09 35			G	1	
161	15	08 30	09 00	08 30		RA	2	Cloud
162	Dec. 7	09 45	10 00			R	2	
163	10	09 00	10 10			—	—	

Ref. No.	Date. U.T.	U.T. of First Obs. h. m.	U.T. of Last Obs. h. m.	U.T. of Maxima. h. m.	U.T. of Minima. h. m.	Main Types.	Intensity.	Remarks.
1937								
164	Jan. 9					—	—	
165	10	10 30	13 00			RA	2	
166	11	08 30	09 30			HA	2	
167	14					RA	2	
168	19	11 15	11 15			R	2	
169	21	07 00	08 15			RA	2	
170	Feb. 3	11 45	12 55			RA	2	
171	4	10 20	10 20			R	2	
172	17					R	1	
173	19	09 30	13 29			RA	2	
174	Mar. 2					—	3	Note 4
175	5	09 15	15 00	09 20		RA	3	Sunlit
				10 28	12 00*	RA	3	Red. P
				13 10p		RA	3	
177	6	09 15	09 45			G	1	
178	10	10 00	11 30			—	2	Cloud
179	13	09 30	09 30	09 30		R	1	
180	15	08 45	15 00	10 52		RB	3-4	Sunlit
				11 57	12 38	RB, D	3-4	Red. P
				12 58		D, F	4	
181	18	09 30	10 15	10 00		RA	2	
182	25	07 30	07 30			G	1	
183	26	07 30	07 30			G	1	
184	29	09 00	09 00			G	1	
185	31	08 00	11 00	08 00		RA, D	3	Sunlit
								Red. P
186	Apr. 1	08 00	09 00			G	1	
187	9	08 50	08 57			G	1	
188	20	08 45	11 00			G	1	
189	27	07 30	08 00			R	1	
190	28	06 15		07 10	07 25	D	4	Sunlit
				07 42	08 00	D	4	Red. P
				08 40	08 50	D	4	
				09 10		D	4	
				10 00		D	4	
				10 27p		D, C, F	4	
				12 45		D, F	4	
191	May 29	06 30	08 34			RA	1	P
192	1	07 15	07 15			—	—	Cloud
193	2	07 30	07 30			—	—	Cloud
194	4	07 38	10 00			RA	2	
195	5	06 25	11 30	07 30		RA, RB, F	4	Red
						DS		Note 5
196	6	06 30	06 30			RA	2	
197	7	11 30	11 50			R	2	
198	8	07 30	15 30			G	1	
199	9	08 30	13 00			G	1	
200	10	07 30	19 00			G	1	
201	17	06 15	07 30	07 00		HA	2	
202	28					R	1	
203	Jun. 5	07 00	07 00			G	1	
204	Jun. 6	07 30	11 30	10 30		RA	3	P. Red
205	11	14 30	12 45	12 30		R	2	
206	13	11 30	11 30			R	2	
207	14	07 30	07 30			G	1	
208	19	07 15	10 00			HA	2	
209	Jul. 4	08 30	08 30			—	—	
210	17	07 30	07 30			HA	2	
211	Aug. 2	09 30	13 00	10 00		RA	4	Red. Cloud
212	4	07 00	10 20	08 24		RA	2	P

Ref. No.	Date. U.T.	U.T. of First Obs. h. m.	U.T. of Last Obs. h. m.	U.T. of Maxima. h. m.	U.T. of Minima. h. m.	Main Types.	Intensity.	Remarks.
213		7 09 00	09 00			G	1	
214		13 07 30	12 30			R	2	
215	Sep.	17 10 40	10 55			G	1	
216		21 08 30	08 30			G	1	
217		22 09 30	09 30			—	—	Cloud
218		23 07 40	08 00			RA	2	
219	Oct.	1 08 00	14 00	08 10p 11 24	09 20*	RA, D, PS	3	Sunlit P
220		2 08 00	12 30			R	1	
221		4 08 00	13 00	09 52		RA	3	Sunlit P. Cloud
222		6 08 00	10 30	08 40		R	1	
223		7 10 55	13 00			RA	2	
224		8 11 30	12 00			G	1	
225		9 08 45	16 30	15 40		RA, D, F	3	Red. P Sunlit Note 6
226		10 08 45	14 20			RA	3	Cloud. P
227		11 13 05	13 50			RA	2	
228		13 08 30	14 00			G	1	
229		14 08 30	14 00			HA	1	
230		15 12 00	12 00			HA, RA	1	
231		18 11 00	11 00			G	1	
232		22 11 00	11 00			G	1	
233		23 09 30	12 15	11 45		RA, PA	2	P
234		24 09 15	12 15	11 45		RA	2	P
235		26 07 40	12 00			RA	2	
236		27 10 30	12 15			G	1	
237		28 08 30	12 45			—	—	Cloud
238	Nov.	2 09 12	09 12			—	2	Cloud
239		28 10 00	14 30	10 55 12 10 13 19	11 40	RA RA, PS	3 3	P. Sunlit
240		29 11 00	11 12	12 30		RA	2	
241	Dec.	23 12 10	12 50			RA	2	
242		31 10 25	10 40			RA	2	
1938								
243	Jan.	5 12 30	13 45			R	1	Cloud
244		21 08 30	11 00	00 30		RA	3	Red
245		22 08 30		10 37p 14 00 13 45		RA, D RA, D	4 4	Red. Cloud Note 7
246		25 13 15				RA	3	Note 8
247		26 09 40				RA	3	Note 8
248		27 08 30				G	1	
249		20 08 50	08 50			G	1	
250	Feb.	1 10 00	12 17			RA	2	P
251		6 09 00	11 30			RA	2	Cloud
252		8 10 30	11 30			RA	1	
253		9 10 55	10 55			G	1	
254		18 09 45	10 00			G	1	
255		20 09 50	11 00			G	1	
256		24 08 55	11 15			G	1	
257		28 09 30	11 00			RA	2	
258	Mar.	1 08 30	12 00			G	1	
259		5 10 25	17 00			RA	2	
260		7 08 30				G	1	
261		22 08 00	15 30	08 45p 11 30	09 50	D, DS, PS D, DS, PS	3 3	Red. P Sunlit
262		23 08 30	10 30			RA	2	Cloud
263		24 08 15	14 00	08 50p 10 00*		D DS, F	3 3	Sunlit P
264		30 08 00	14 00			—	2	Cloud

Ref. No.	Date. U.T.	U.T. of First Obs. h. m.	U.T. of Last Obs. h. m.	U.T. of Maxima. h. m.	U.T. of Minima. h. m.	Main Types.	Intensity.	Remarks.
265	Apr. 4	08 15	10 00			G	1	
266	7	11 15	14 30			RA	2	P
267	15	10 30	10 30			G	1	
268	16	07 00	15 45	07 55 10 30 14 15	10 18 13 46	D, C D, C RA, F	4 4 4	Sunlit Red. P Note 9 Red. Cloud
269	17					—	—	
270	22	10 30	10 30			G	1	
271	23	07 20	15 30	11 30		RA, D, F, PS		Red. P Note 10
272	24	07 30	10 30			HA	1	P
273	25	08 00	13 33	10 50 13 00p		RA RA HA	2 2 1	P P P
274	26	07 30	11 30			HA	1	P
275	May 1	07 30	12 00			G	1	
276	2	07 15	08 35			—	—	Cloud
277	3	07 30	14 50			G	1	
278	4	08 00	10 00			G	1	Cloud
279	12	08 30	09 30			RA	2-3	
280	17	16 30	16 30			G	1	
281	20	08 00	10 00			G	1	
282	28					G	1	
283	29	06 30	17 00	12 13		RA, PA	3	P. Red
284	30	07 30	07 30			G	1	
285	Jun. 7	08 00	10 00			R	2	
286	9	07 30	12 30			G	1	
287	18	12 00	12 15			R	2	
288	21	11 00	11 00			—	—	Cloud
289	23	10 30	10 30			G	1	
290	25	11 00	12 00			G	1	
291	26	07 30	11 20			—	—	Cloud
292	Jul. 1	10 50	17 30			HA	2	Fog
293	4	12 00	17 00			HA	2	
294	11	07 30	12 00			HA	2	
295	13	07 30	10 30			G	1	
296	15	07 30	12 00	10 20		RB	3	P
297	16	07 30	12 00	09 15		RA	2	P
298	19	11 00	11 30			—	—	Cloud
299	25	07 30	11 30			G	1	
300	26	07 30	12 30			G	1	
301	27	07 30	11 30			G	1	
302	30	06 30	12 00	06 45 08 30 11 00p		RA RA D, F	3 3 3-4	Red. P
303	31	11 45	11 45			R	2	
304	Aug. 1	15 30	15 30			G	1	
305	4	07 05	12 00	08 30 10 30		RA RA	3 3	Red. P
306	5	07 30	10 00			G	1	
307	23	08 50	11 15	09 30 10 50p	10 15*	RA RB	2 3	Red. P
308	26					—	—	Cloud
309	Sep. 6	08 30	08 30			—	—	Cloud
310	12	11 30	11 30			G	1	
311	14	07 55	11 30			G	1	
312	15	07 30	15 30	08 00p 11 20p 12 25		HA, RA D, C F, DS	4 4 4	Red. P Note 11
313	Sep. 16	07 30	08 00			G	1	
314	22	09 20	10 50	09 55		HA	1-2	
315	26	07 30	17 30	10 00 12 58		RA, DS PS, D, F	3 3	Red. P

Ref. No.	Date. U.T.	U.T. of First Obs. h. m.	U.T. of Last Obs. h. m.	U.T. of Maxima. h. m.	U.T. of Minima. h. m.	Main Types.	Intensity.	Remarks.
316		27 10 40	10 40			G	1	
317	Oct.	7 10 15	15 00			RA	2	Cloud
318		13 08 00	11 00			G	1	
319		14 10 10	10 10			—	—	Cloud
320		15 12 00	12 00			G	1	
321		16 11 00	12 15	11 00		R	1	
322		17 10 00	11 30			G	1	
323		20 08 45	11 00			—	—	Cloud
324		23 10 30	11 30			R	1	
325		24 08 45	16 00			R	2	
326		25 09 30	12 15	11 55		PA, D, F	3	P
327		26 09 00	10 45			RA	1.2	
328		27 11 00	12 30			RA	2	
329		29 15 30	15 30			—	—	Cloud
330		30 11 15	11 15			—	—	Cloud
331	Nov.	2 10 30	10 30			G	1	
332		11 09 30	10 00			G	1	
333		12 09 30	10 00			G	1	
334		13 10 00	10 00			—	—	Cloud
335		17 10 15	12 00	10 15		RA	2	
336		18 10 00	10 30			R	1	
337		19 11 00	11 00			—	—	Cloud
338		25 10 30	10 30			G	1	
339		26 11 00	11 00			R	1	
340		27 10 30	10 30			G	1	
341		29 10 30	10 30			G	1	
342	Dec.	11 11 00	11 30			G	1	
343		12 11 30	11 30			G	1	
344		17 09 30	10 15			R	1	
345		21 09 30	11 30			R	2	
346		22 09 50	11 30			—	2.3	Cloud
347		23 09 00	10 30			G	1	
348		24				—	1	Cloud

NOTE 1.—Nos. 14, 15, 16—1933, January 19, 28, February 16. There is a very slight possibility that these were not aurorae, but they have been included as no other explanation of the phenomena seen can yet be found.

NOTE 2.—No. 40—1934, April 9. This showed a most unusual auroral type consisting of bursts of light very similar in appearance to *Verrey Lights*.

NOTE 3.—No. 47—1934, July 30. This was remarkable for the quietness of the main HA, this persisting without appreciable change for some four hours.

NOTE 4.—No. 174—1937, March 2. Beyond the fact that a very bright aurora occurred on this night, nothing is known of the display. The only report available is a newspaper paragraph.

NOTE 5.—No. 195—1937, May 5. The reports of this aurora are vague, although fairly numerous, and it is difficult to determine the type. It was certainly of a very unusual nature, however, with segments of arcs and bands in the zenith, quite detached from the main aurora.

NOTE 6.—No. 225—1937, October 9. It has proved impossible to determine secondary maxima here. The aurora appeared to be only the commencement of a much larger display; this is supported by the occurrence of quite a good aurora the following night.

NOTE 7.—No. 245—1938, January 22. Information about this great aurora is not very complete, owing to the fact that no observations are available south of latitude 41°, the entire South Island experiencing a very cloudy night.

NOTE 8.—Nos. 246 and 247—1938, January 25 and 26. Between these two displays there occurred the great European aurora of January 25. Undoubtedly New Zealand here recorded the beginning and ending of the main disturbance. This was at the time the subject of a letter to *Nature*.\*

NOTE 9.—No. 268—1938, April 16. In the case of this display all three maxima were of about equal intensity, although the last differed vastly in type.

NOTE 10.—No. 271—1938, April 23. The last observations were made through heavy fog. At this time activity seemed to be increasing again, and the aurora as a whole was showing no signs of dying out.

NOTE 11.—No. 312—1938, September 15. The feature of this aurora was the high, detached arc which appeared at the time of the first maximum and remained visible for about an hour. It was entirely separated from the main aurora and was remarkably stable. The rare occasions when such arcs have been seen previously have been discussed by Störmer.†

TABLE II.—AURORAL TYPES.‡

Type	Abbreviation.	Description.
Glow	G	Feeble glow near the horizon, of white, green, yellow, or reddish colour. Often the reflection of a display further south.
Homogeneous Quiet Arc	HA	An arc or bow of light standing clear of the horizon except at the ends. It may be single, double, or multiple.
Homogeneous Bands	HB	Similar to the HA form, but more irregular.
Pulsating Arc	PA	An entire arc or segment of an arc pulsating with a period of several seconds.
Diffuse Luminous Surfaces	DS	A detached cloud-like form, usually without definite boundaries. Brilliant red colouring is often a feature of them.
Pulsating Surfaces	PS	DS forms pulsating.
Arcs with ray structure	RA	An arc surmounted by rays, or composed of rays. The logical development of the HA form.
Bands with ray structure	RB	The development from the HB form.
Draperies	D	Very long rays surmounting a folded arc or band, giving the effect of a hanging drapery.
Rays	R	Isolated rays, not lying in an arc formation.
Corona	C	A perspective effect produced in the magnetic zenith when the rays from the RA, RB or D become sufficiently long to appear to meet in a point.
Flaming Aurora	F	Waves or ripples of light moving up from the horizon across the main forms. A characteristic of very intense aurorae.

\* White, Skey, and Geddes—Radio Fade-outs, Auroras, and Magnetic Storms, *Nature*, August 13, 1938.

† Störmer—Remarkable Aurora Forms from Southern Norway, *Geofysiske Publikasjoner* XI, 12, Oslo, 1936.

‡ For a full discussion of auroral types and photographs see the Photographic Atlas of Auroral Forms, *International Geodetic and Geophysical Union*, Oslo, 1930.

TABLE III.—INTENSITY SCALE.\*

Scale.	Intensity.	Features.	Phenomena with similar intensity.	Time of Exposure.
0	Nothing to be seen			
1	Faint	Very faint beams, arcs and remnants	Galaxy	1m.-2m.
2	Moderate	Quiet regular arcs	Cirrus cloud in moonlight	20sec.
3	Bright	Rays and draperies	Cumulus in moonlight	7sec.
4	Very bright	Bright draperies		1sec.-2sec.

In this table the time of exposure has been added as a further indication of the relative brightness of the various scale values.

#### RED AURORAE.

Brilliant red colouring does not accompany the normal auroral display, but during a period of maximum activity such as that of 1937 and 1938 red forms appear to be much more numerous than in other years. In Table I aurorae which showed brilliant red colouring at various stages have been indicated by the word "red" in the remarks column. In all, it will be seen that there are 23 such displays, only 4 of which occurred before 1937. In two cases the red was confined to the lower border of an active arc just before the RA stage, but in all the other cases it took the form of red rays merging to diffuse red patches.

#### SUNLIT AURORAE.

When an aurora occurs in the early evening or before dawn sunlit forms may occur. In such cases the main forms are in the dark region of the atmosphere, but the upper portions, usually of rays, are in the full sunlight. The appearance is usually quite characteristic, the rays undergoing a change of colour as they cross the shadow-line. Occasionally there is a gap between the two portions of the ray. In some cases, however, it is possible to determine whether the ray is sunlit only by measurement of photographs. For this reason the indication "sunlit" in the remarks column does not appear so frequently in the case of the 1938 displays, for the photographs taken that year have not yet been measured.

#### DIFFUSE SURFACES.

During the years of minimum activity there were a number of aurorae which consisted of very faint luminous arcs or bands without definite boundaries. They appear to have occurred well to the north of the usual zone of the New Zealand aurorae (Auckland Islands) and, in some cases, actually over New Zealand. Since 1936, however, they have been conspicuously absent, and it appears at present that they may be characteristic only of minimum years.

\* This table is due to D. la Cour, and may be found in *Supplements to the Photographic Atlas of Auroral Forms*, Oslo, 1932.

## GREAT AURORAE.

This term is used to refer to aurorae which reach unusual brilliance. It is a purely relative term, corresponding to the same term used to describe magnetic storms. The following aurorae occurring during the period may be described as "great":—

1937, April 28; 1938, April 16; 1933, September 9;

1938, January 22.

An effort has here been made to arrange them in order of magnitude, a rather difficult process, as it is not easy to allow for such factors as cloud hindrance, varying types, etc. All were exceptionally brilliant and very active. In every case where reliable observations could be made in Southland a corona developed during the maximum period. In each case also the forms at certain stages occurred actually over New Zealand, in some cases over the North Island. One other aurora, 1938, September 15, fell only a little short of the displays listed.

## PHOTOGRAPHIC WORK.

Since the end of 1936 two photographic stations have been in operation in Southland. The discussion of the photographs taken does not come within the scope of this paper. The aurorae photographed have been indicated by the letter "P" in the remarks column.

## Observation of Meteors for the Years 1935-1938 in New Zealand.

### FOURTH REPORT OF THE METEOR SECTION OF THE N.Z. ASTRONOMICAL SOCIETY, INC.

By R. A. McINTOSH, F.R.A.S.

[Read before the Wellington Branch, July 26, 1939; received by the Editor,  
July 27, 1939; issued separately, March, 1940.]

THIS report, covering the work performed in the four-year period 1935-38, is the fourth published by the Meteor Section of the New Zealand Astronomical Society, Inc., the earlier reports having been published in *Transactions of the New Zealand Institute*, vol. 60, p. 448, and vol. 63, p. 443, and *Transactions of the Royal Society of New Zealand*, vol. 66, p. 60. These reports have been reprinted and distributed as Bulletins nos. 5, 21 and 24 of the New Zealand Astronomical Society.

The attention of members of the Meteor Section has been concentrated mainly on the ordinary routine of recording meteors in extended watches for the purpose of determining centres of radiation and rates of activity. The work has proceeded very slowly, because the personnel has always been small, but the experience gained by members over the years has resulted in a very satisfactory standard of accuracy being attained.

As a result of this steady endeavour on the part of a few, the total meteors recorded by the section during the twelve years of its existence is 13,126, from which over one thousand radiants have been deduced. While this figure is no more than other meteor groups can produce in a single year, it must be remembered that the New Zealand work is being performed in the southern celestial hemisphere, where no other group or individual has observed for more than a short period. The data we are collecting are therefore of particular value in many ways.

A stage has now been reached when the section must gain fresh observers if the valuable work is to continue. One of our most energetic members, Mr. M. Geddes, has now become Director of the new Carter Observatory, upon which his friends in the Meteor Section most heartily congratulate him. This appointment robs the section of a very active worker. Similarly, our work has now reached a stage where the writer must concentrate more upon the production of articles covering many phases of the work achieved, together with theoretical papers, and will probably in the next year or so be able to find time only for special researches as the need arises. It is to be hoped, therefore, that members of the Society who are not actively observing will step into the breach and help to continue the work.

The following table summarises the work performed during the period covered by the report:—

Observer.				Nights.	Time.	Meteors.
					h. m.	
Bateson (B)	..	..	1		2 35	18
Geddes (G)	..	..	39		74 4	1,162
Fairbrother (F)	..	..	34		73 44	874
McIntosh (M)	..	..	33		40 15	940
Total				107	190 38	2,994

Reports of telescopic meteors were received from members of the New Zealand Astronomical Society during the period as follows:—Bateson, 3; Bryce, 1; Geddes, 22; McIntosh, 14; Morshead, 5; Smith, 15; Sofield, 1. Total, 61.

Details of fourteen bright fireballs have been collected from the public, most of which await investigation. (Unfortunately, although they contain several very interesting objects, publication cannot be achieved while more important meteoric topics are awaiting attention.) Large numbers of observations of isolated fireballs are also in hand, and my thanks are due to the Dominion Observatory, the Carter Observatory, and many individuals too numerous to mention, for making these reports available.

The seven papers published during the period by the Director are indicative of the results achieved by the Meteor Section to date. The Ephemeris of the Eta Aquarid Radiant (*Monthly Notices Royal Astron. Soc.*, 95, 7, 601; 1935, May), while tracing the day-to-day motion of this radiant, also demonstrated the accuracy which can be attained in visual meteor work, and is especially valuable at the present time while mathematicians are attempting to disparage the amateur meteor worker. The Index to Southern Meteor Showers (*Monthly Notices Royal Astron. Soc.*, 95, 8, 709; 1935, June) is particularly valuable to members of our Section in that it provides the first indication of what minor radiants may be expected at any time.

The Velocities of Meteor Streams (*Monthly Notices Royal Astron. Soc.*, 96, 7, 704; 1936, May), The Telescopic Determination of Meteor Radiants (*Journal Brit. Astron. Assoc.*, 46, 2, 73; 1935, Dec.), and Meteor Static (*Journal Brit. Astron. Assoc.*, 44, 3, 123; 1937, Jan.) open up new ground. In The Determination of the Real Paths of Fireballs (*Journ. R.A.S. Canada*, 32, 1, 1; 1938, Jan.) a complete method of dealing with large numbers of reports by inexperienced observers is published, I believe, for the first time in English. Finally, the first indication of the variation in the numbers of meteors throughout the year was given in a paper read at the Auckland sessions of the Australian and New Zealand Association for the Advancement of Science and later published in America (*Popular Astronomy*, 46, 9, 516; 1938, Nov.).

In the preparation of this report the existence of some radiants additional to those listed in the *Index to Southern Meteor Radiants* was disclosed. These are given in the following table:—

## NEW RADIANTS.

No.	Duration.		Radiant.	No. of Radiants.	Name.
321	Aug. 30–Sept. 6	..	13°—9° 19 — 6	5	21 Cet.
322	Aug. 2–4	..	39 —16	3	Pi Cet.
323	April 17–25	..	200 —24	4	— Vir.
324	May 7	..	257 —13	2	Omricon Ser.
325	May 19–31	..	252 —20 257 —24	7	Eta Oph.
326	April 10–15	..	253 —53 260 —50	4	Beta Ara.
327	June 10–16	..	262 —35	2	Lambda Ser.
328	June 2–14	..	269 —33 277 —35	7	Delta Sgr. ii.
329	May 30–June 4	..	285 —18	2	U Sgr.
330	June 2–16	..	284 —23	7	Lambda Sgr. i.
331	June 4–8	..	296 —25	3	Omega Sgr.
332	June 14–21	..	296 —36	2	— Sgr.
333	July 1–11	..	324 —15 .30 —14	4	Iota Aqr. i.
334	July 10–11	..	332 —32	2	Mu PsA.
335	Aug. 13–20	..	330 —9 338 —4	3	Rho Aqr.
336	August 2	..	330 —4	3	30 Aqr.
337	July 22–Aug. 1	..	342 —32 347 —32	6	Delta PsA.
338	Aug. 2–10	..	344 —15 356 —15	7	94 Aqr.

In listing two accordances of observed radiants with the predicted radiants of periodic comets the remarks in the second report must be borne in mind. The publication of such agreements does not necessarily indicate that the meteors are definitely debris of the comets particularly named.

## COMET ACCORDANCES.

Object.	Date.	Radiant.	Remarks.
Comet Schaumasse ..	Mar. 30	298.5°—9.6°	Davidson.
Radiant 859 ..	Apr. 3	294 —99	4/6 meteors.
Comet 1877 ii ..	Aug. 9	32.0 —18.5	Weiss.
Comet 1852 ii ..	Aug. 10	40.5 —13.5	Weiss.
Radiant 1000 ..	Aug. 2	39.0 —17.5	4 meteors.

In the following table the details concerning the various observations are given in the manner usual to these reports. Apart from the date and time spent observing, from which the hourly rate is derived, a factor is estimated by each observer allowing for any hindrances to observing such as clouds or haze. With this factor the observed rate is corrected to a theoretical rate (column 8) for perfect observing conditions. The estimation of rates is not attempted in very short watches or where the factor is so small as to cast doubts upon the reliability of the corrected rate deduced.

Some interesting points can be gleaned from a perusal of this table, which can only be indicated here. Take, for example, the date, 1935, May 6. Observing about the same time, Fairbrother saw 14 meteors an hour in a clear sky, while McIntosh saw 26 an hour, also in clear sky. The difference between the rates can safely be ascribed to the inexperience of the former observer, who had just commenced working for the Section, and who apparently missed a number of the fainter meteors. The higher rates obtained by Geddes, on the other hand, when compared with those of McIntosh (both experienced observers) is an index to the difference between country and town observations.

# DETAILS OF OBSERVATIONS.

N.Z.M.T.	Began. h. m.	Ended. h. m.	Total. m.	Meteors.	Rate.	Factor.	Cor. Rate.	Observer.	Station.	Remarks.
1935										
Jan. 5	22 23	23 33	60	2	2	1.0	2	G	NP	Clear; 10 m. gap.
26	20 40	22 16	61	7	7	0.6	12	G	NP	Passing cloud; 25 m. gap.
28	21 15	21 20	5	1	—	—	—	G	NP	Stopped by clouds.
29	20 46	23 35	229	53	14	1.0	14	G	NP	Clear.
Feb. 1-2	23 00	02 05	185	23	7	1.0	7	F	T	Clouds in south.
3	00 00	02 15	135	24	11	0.9	12	F	T	Clouds after 1.30.
4	00 00	01 05	65	7	7	0.9	12	F	T	Misty horizon.
Mar. 1-2	23 25	02 25	180	27	9	0.9	10	F	T	Haze in N.E.
30	01 30	02 31	61	5	5	1.0	5	F	T	Clear; moon 2½d.
31	00 00	02 00	120	21	10	1.0	10	F	T	Clear.
Apl. 4	02 20	04 20	120	33	16	1.0	16	M	A	Clear.
11-12	23 25	00 15	50	8	9	1.0	9	G	O	Clear.
12-13	23 40	02 00	140	25	11	1.0	11	F	T	Clear.
14	02 30	04 05	95	18	12	1.0	12	F	T	Clear.
May 1	(01 20	02 24)								
	(02 58	03 45)	179	24	8	—	—	G	O	Much cloud.
3	01 44	02 00	16	8	31	—	—	G	O	Passing cloud.
4	02 20	04 15	115	26	13	0.9	14	F	T	Slight haze.
4	02 48	04 20	92	32	22	0.8	28	M	A	Totally clouded 50 m.
6	01 00	04 45	225	53	14	1.0	14	F	T	Clear.
6	02 45	04 20	95	44	26	1.0	26	M	A	Clear.
7	03 31	05 10	120	62	31	1.0	31	M	A	Clear.
8	02 45	05 15	150	58	23	1.0	23	M	A	Clear.
9	03 58	04 43	45	25	33	1.0	33	M	A	Clear.
30-31	22 32	00 39	127	28	14	1.0	14	G	O	Clear.
June 2	01 15	03 16	121	26	13	1.0	13	F	T	Clear.
8	01 53	03 17	84	30	21	1.0	21	G	O	Clear.
July 4	02 55	04 30	95	20	12	1.0	12	M	A	Clear.
6	03 12	03 48	31	13	25	1.0	25	M	A	Misty; 5 m. gap.
7	00 15	03 00	165	39	14	1.0	14	F	T	Clear.
11	03 07	04 53	106	40	23	1.0	23	M	A	Clear.
11	22 05	24 00	115	7	3	0.6	5	F	T	Moon 10d.
12	03 16	04 40	84	26	22	1.0	22	M	A	Clear.
25	22 51	23 23	22	4	12	—	—	G	O	Half cloud; 10 m. gap.
27	02 00	03 06	66	21	19	0.8	24	F	T	Intermittent cloud.
27	03 30	03 56	26	23	30	—	—	M	A	Clear.
28	00 00	02 35	155	71	28	1.0	28	F	T	Clear.
28	01 12	02 36	84	40	28	1.0	28	M	A	Clear.
29	00 06	03 00	174	89	30	1.0	30	G	O	Clear.
30-31	23 40	01 35	115	53	28	1.0	28	F	T	Clear.

N.Z.M.T.	Began. h. m.	Ended. h. m.	Total. m.	Meteors.	Rate.	Factor.	Cor. Rate.	Observer.	Station.	Remarks.
Aug. 1	02 27	04 27	120	81	40	1.0	40	G O		Clear.
1	02 30	03 31	61	33	33	1.0	33	M A		Clear.
1	04 02	04 32	30	17	34	1.0	34	M A		Clear.
2	22 30	23 50	80	27	20	1.0	20	F T		Clear.
3	00 16	04 16	240	132	33	1.0	33	G O		Clear.
3	02 40	04 15	93	46	30	1.0	30	M A		Clear.
7	01 33	02 45	72	32	27	0.9	30	G O		Passing cloud.
8	00 45	02 45	120	27	13	0.8	17	F T		Passing cloud.
10	02 30	04 00	90	27	18	1.0	18	F T		Clear.
31	00 25	02 35	130	27	13	1.0	13	F T		Clear.
Sept. 1	00 00	02 00	120	26	13	1.0	13	F T		Clear.
1-2	23 00	01 10	130	26	12	1.0	12	F T		Clear.
3	00 00	02 20	140	28	12	1.0	12	F T		Clear.
29	00 20	02 00	100	17	10	1.0	10	F T		Clear.
Oct. 18-19	23 12	00 55	103	11	7	0.8	9	F T		Passing cloud.
21	(02 35	03 06)								
	(03 22	03 30)	39	12	18	0.7	26	M A		Clear; moon 22d.
Nov. 22-23	22 50	01 30	160	15	6	1.0	6	F T		Clear.
27	00 00	02 13	135	24	11	1.0	11	F T		Clear.
Dec. 22	22 20	23 20	60	11	11	1.0	11	G NP		Clear.
26	02 25	02 57	32	10	19	0.7	27	G NP		Dawn.
1936										
Feb. 26-27	23 07	00 33	86	18	12	1.0	12	G O		Clear.
28-29	22 00	01 05	185	27	9	1.0	9	F CI		Clear.
Ap. 17-18	(23 47	00 05)								
	(00 25	01 02)	55	11	12	1.0	12	G E		Clear.
25	20 20	23 35	195	21	7	0.9	8	F CI		Haze on horizon.
27	02 30	04 00	90	11	7	0.7	10	G E		Fog and haze.
27	02 37	03 45	68	9	9	1.0	9	M A		Clear.
28	02 30	04 35	125	26	13	1.0	13	G E		Clear.
29	02 30	03 35	65	5	5	0.4	12	G E		Very foggy.
June 16-17	23 04	00 44	100	33	20	1.0	20	G E		Clear.
21-22	22 20	00 20	120	36	18	1.0	18	G E		Clear.
22	22 23	22 57	34	3	6	0.9	6	G E		Hazy.
Jul. 10-11	23 00	01 00	120	17	8	0.5	16	F CI		Moon last quarter.
15	02 32	03 42	70	14	12	1.0	12	M A		Clear.
16	02 30	02 50	20	3	6	—	—	M A		Misty, then clouded.
16	21 45	23 52	127	27	13	1.0	13	F CI		Clear.
16-17	23 00	00 09	69	19	17	1.0	17	G E		Clear.
22-23	22 29	00 29	120	36	18	1.0	18	G E		Clear.
23	03 07	04 45	98	30	18	1.0	18	M A		Clear.
24	02 37	04 37	120	44	22	0.9	24	M A		Fog ½ time.
24-25	22 30	00 16	106	27	15	0.9	17	F CI		Few passing clouds.
25	02 35	04 44	123	60	30	1.0	30	M A		Clear.
29	02 31	04 41	130	73	34	1.0	34	M A		Clear.
Oct. 17	02 20	02 54	34	11	19	0.9	21	M A		Misty.
20	02 05	03 50	105	46	26	0.9	29	M A		Misty cloud.
21	02 00	03 28	88	44	30	1.0	30	M A		Clear.
1937										
May 28	17 53	19 08	75	14	11	0.6	18	G C		Intermittent watch; cloud.
29	18 42	20 04	82	16	12	0.7	17	G C		Passing cloud.
30	18 23	20 25	122	14	—	—	—	G C		Considerable cloud.
31	20 10	21 40	90	19	12	0.9	13	G C		Slight cloud.

N.Z.M.T.	Began. h. m.	Ended. h. m.	Total. m.	Meteors.	Rate.	Factor.	Cor. Rate.	Observer.	Station.	Remarks.
June 1	19 50	22 10	140	23	8	0.8	10	G C	C	Passing cloud.
2	18 37	23 05	268	47	10	0.9	11	G C	C	Passing cloud.
3-4	20 00	00 15	255	56	12	0.9	13	G C	C	Passing cloud.
4	20 00	23 55	235	45	12	0.8	15	G C	C	Passing cloud.
5-6	21 30	01 00	210	53	14	0.8	17	G C	C	Passing cloud.
9	00 10	03 10	180	53	18	0.9	20	G C	C	Passing cloud.
13-14	23 00	00 25	85	26	18	1.0	18	G Ap		Clear.
June 14-15	22 15	00 35	140	35	15	0.9	17	G Ap		Clear.
July 28	20 33	21 40	67	7	6	0.2	—	G SH		Through cloud gaps.
1938										
Feb. 9	02 53	03 53	60	13	13	1.0	13	M A		Clear.
Mar. 2	02 00	03 30	90	14	9	1.0	9	M A		Clear.
9	01 57	02 15	18	4	13	—	—	M A		Clear.
May 7	00 25	02 55	150	27	10	1.0	10	F Td		Clear.
7	03 15	05 00	105	27	15	1.0	15	F Td		Clear.
8	02 40	04 50	130	41	19	1.0	19	M A		Clear.
June 3	02 42	03 52	70	13	12	1.0	12	M A		Clear.
Oct. 19	01 50	02 00	10	2	—	—	—	M A		Clear, then clouded.
20	01 50	02 00	10	2	—	—	—	M A		Clear, then clouded.
Dec. 17-18	23 15	01 50	155	18	7	0.8	9	B W		Some cloud.

In the column "Observer" the various observers are denoted as follows: Bateson (B), Fairbrother (F), Geddes (G), and McIntosh (M). The observing stations also are abbreviated: Auckland (A), Apia, Samoa (Ap), Canton Island, N.Z. Solar Eclipse Expedition's site (C), Chatham Island (CI), Ermedale, Southland (E), New Plymouth, Taranaki (NP), Otekura, Southland (O), South Hillend, Southland (SH), Tadmor, Nelson (T), Taradale, Hawke's Bay (Td), Wellington (W).

The list of radiant which follows is in the same form as that used in the previous reports, being arranged in order of date (irrespective of year), at least four meteors observed on one night and intersecting within a circle 2 degrees in diameter, or five meteors on adjacent nights, or one stationary meteor, being required to form a radiant.

Criticism has been levelled at the number of radiants in earlier reports based on very few meteors. The Director is reluctant to abandon these, in a practically virgin field such as we are working in. Some consolation can be derived from the fact that 75 per cent. of the present list find confirmation in other radiants observed in New Zealand or elsewhere, which is indicated by naming the radiant in the "Remarks" column. Actually a portion of any radiant list must be erroneous, and the same faith cannot be placed in a list such as the present one as can be given to the *Index Catalogue* previously mentioned.

#### LIST OF RADIANT POINTS OBSERVED.

No.	Date G.M.T.			Radiant.				L.			Remarks.
				R.A.	Dec.	Mets.	Wt. Obs.				
846	1935	Jan.	29.47	120.0	-63.8	5/6	G G	219.3			
847	"	"	"	126.7	-15.0	4	G G	"			
848	"	"	"	144.7	-23.0	4	G G	"			Inc. 2 stationary
849	"	"	"	147.0	-57.0	4	G G	"			NZ 853.
850	"	"	"	187.5	-42.0	8	G G	"			
851	"	"	"	189.0	-35.5	5	G G	"			NZ 611.
852	1935	Feb.	1-3c	206.0	-44.0	8	F F	222.3			Diffuse. Mu Cen.

No.	Date G.M.T.	Radiant.		Dec.	Mets.	Wt.	Obs.	L.	Remarks.
		R.A.	R.A.						
853	1935	Feb.	3.57	144.5	-50.7	4/7	G F	223.3	1 meteor Feb. 2. NZ 849;
854	1936	Feb.	26.51	242.0	-45.3	6	G G	245.0	[BAA 153.
855	1938	Mar.	1.63	180.0	-18.5	5	G M	249.7	Eta Cra.
856	1935	Apl.	3.66	190.0	-6.0	3/5	F M	282.1	D. 147, 3.
857	"	"	"	241.0	-41.5	4/5	G M	"	"
858	"	"	"	279.3	-34.5	4	G M	"	Delta Sgr.
859	"	"	"	294	-9	4/6	F M	"	Comet Schaumasse.
860	1935	Apl.	12-13c	235.0	-34.5	4	G F	291.0	NZ 269.
861	"	"	"	253.0	-53.5	4/6	F F	"	Beta Ara.
862	"	"	"	282.5	-17.3	5	G F	"	D. 226, 3.
863	1936	Apl.	17.37	201.5	-28.0	4	G G	296.3	— Vir.
864	1936	Apl.	25.44	200.0	-15.5	5/6	G F	304.1	? Alpha Vir.
865	"	"	"	201.0	-27.5	3/4	G F	"	— Vir.
866	1936	Apl.	27.67	256.7	-20.3	3/4	F G	306.3	1 meteor Apl. 26. NZ 632.
867	"	"	"	310.0	-31.5	5/7	G G	"	? NZ 666.
868	"	"	"	333.5	-29.7	6	G G	"	? NZ 663. Zeta PsA.
869	1935	Apl.	30.63	280.5	-64.0	4/5	G G	308.5	"
870	"	"	"	299.5	-53.0	4	G G	"	"
871	1935	May	3.66	262	-24	5	F F	311.5	"
872	"	"	"	284.5	-22.0	4/5	F F	"	NZ 633, 639b.
873	"	"	"	340	-3	3/4	P F	"	"
874	1935	May	3.67	335.0	-2.0	13	G M	"	Eta Aqr.
875	1935	May	5.64	251.0	-33.0	5	G F	313.5	"
876	"	"	"	336.5	-1.0	10	G F	"	Eta Aqr.
877	1935	May	5.67	279.5	-43.8	3/4	G M	"	"
878	"	"	"	292.5	+2.0	4	G M	"	NZ 347; D. 230, 5.
879	"	"	"	336.5	-0.6	12	G M	"	Eta Aqr.
880	1938	May	6.63	319.5	-10.0	4/5	G F	314.8	"
881	"	"	"	321.0	+6.0	3/4	G F	"	"
882	"	"	"	338.0	-2.0	9	G F	"	Eta Aqr.
883	1935	May	6.69	239.0	-34.8	4/5	G M	314.5	— Scr.
884	"	"	"	307.0	+11.5	4	G M	"	1 meteor May 5. D. 236, 4.
885	"	"	"	338.0	0.0	32	G M	"	Eta Aqr.
886	1938	May	7.68	337.5	-1.0	21	G M	315.8	Eta Aqr.
887	1935	May	7.69	268.0	-11.5	3/4	F M	315.5	"
888	"	"	"	339.0	+0.5	27	G M	"	Eta Aqr.
889	1935	May	7-8c	325.0	-19.0	5/6	G M	315.9	Gamma Cap.
890	1935	May	8.73	340.0	+1.0	14	G M	316.4	Eta Aqr.
891	1935	May	30.50	245.5	-36.0	4/6	F G	337.8	NZ 688.
892	"	"	"	283.7	-43.0	4	G G	"	"
893	"	"	"	285.0	-18.0	4/5	G G	"	U Sgr.
894	"	"	"	336.5	-65.5	2	G G	"	Inc. 1 stationary.
895	1937	May	31.39	234.5	+2.5	4	G G	339.0	? Mu Ser. ii.
896	"	"	"	240.0	-24.3	5	G G	"	Omega 2 Ser.
897	1937	June	1.40	267.5	-21.3	6	F G	340.0	2 meteors May 31. 4 Sgr.
898	1935	June	1.61	330.3	-21.5	4	F F	339.6	Poor in dec.
899	"	"	"	336.4	-37.5	5	G F	"	NZ 930?
900	1937	June	2.30	244.5	-29.6	5	G G	341.0	1 meteor June 1. 13 Ser.
901	"	"	"	252.5	-14.0	10	G G	"	1 meteor June 1. Xi Oph.
902	"	"	"	254.5	+14.8	6	G G	"	2 meteors June 1.
903	"	"	"	269.0	-33.5	4/6	F G	"	Delta Sgr. ii.
904	"	"	"	269.5	-22.5	4/7	G G	"	? Phi Sgr.
905	"	"	"	284.0	-29.0	5	F G	"	3 meteors June 1. Lambda.
906	1937	June	3.44	210.0	-26.5	6	F G	341.9	[Sgr. i.
907	"	"	"	227.7	+10.7	4/6	P G	"	"
908	"	"	"	239.0	-12.7	6	G G	"	Omega 2 Ser.?
909	"	"	"	253.5	-27.5	6	G G	"	? Xi Oph. ii.
910	"	"	"	262.3	-11.0	4	G G	"	Omicon Ser. i.
911	"	"	"	269.0	-32.5	6	G G	"	Delta Sgr. ii.
912	"	"	"	293.5	-32.7	3	G G	"	Meteors close to rad.
913	1937	June	4.44	244.5	-28.4	5	G G	342.8	2 meteors June 3. 13 Ser.
914	"	"	"	248.5	-23.0	4	P G	"	Omega 2 Ser.

No.	Date G.M.T.			Radiant.		Mets.	Wt.	Obs.	L.	Remarks.
				R.A.	Dec.					
915	"	"	"	258	—27	4	G	G	"	Xi Oph. ii.
916	"	"	"	271.5	—32.0	6/7	G	G	"	Delta Sgr. ii.
917	"	"	"	284.0	—19.0	4	P	G	"	U Sgr.
918	"	"	"	296.0	—20.5	5	G	G	"	Omega Sgr.
919	1937	June	5.49	230.0	—37.0	0	G	G	343.8	
920	"	"	"	245.5	—12.5	3/4	P	G	"	Omega 2 Ser.
921	"	"	"	250.5	—52.0	5/0	G	G	"	? Rho 2 Ara ii.
922	"	"	"	267.3	—11.4	5/8	F	G	"	Omicron Ser. i.
923	"	"	"	272.0	—47.5	5	G	G	"	
924	1935	June	7.03	267.5	—24.5	4	F	G	345.4	? Phi Sgr.
925	"	"	"	290.0	—25.0	4	G	G	"	Omega Sgr.
926	"	"	"	326.0	—42.5	4/0	G	G	"	
927	1937	June	8.59	296.5	—21.3	9	G	G	346.8	Inc. 1 stat'n'ry. Omega Sgr.
928	"	"	"	310.0	—9.0	4	P	G	"	
929	"	"	"	323.0	—20.5	4/5	G	G	"	
930	"	"	"	335.5	—32.0	4	G	G	"	NZ 899?
931	1937	June	13.51	279.5	—21.0	3/5	P	G	351.7	Diffuse. Lambda Sgr. ii.
932	"	"	"	286.5	—17.5	5	G	G	"	? Rho 1 Sgr.
933	"	"	"	294.0	+ 4.0	4	G	G	"	NZ 937; D. 230, 7.
934	1937	June	14.50	266.0	—13.0	8	G	G	352.7	Omicron Ser. i.
935	"	"	"	283.5	—21.5	6	G	G	"	Lambda Sgr. i.
936	"	"	"	295.0	—36.5	5/0	G	G	"	— Sgr.
937	"	"	"	296.0	+ 4.0	4	G	G	"	NZ 933; D. 230, 7.
938	1936	June	16.52	57.0	—64.0	1	G	G	354.8	Stationary meteor.
939	"	"	"	256.0	—45.3	5/6	G	G	"	
940	"	"	"	263.0	—33.5	4/6	F	G	"	Lambda Ser.
941	"	"	"	290.0	—26.5	4	G	G	"	Chi 1 Sgr.
942	1936	June	21.49	273.0	—34.0	6/7	G	G	359.7	? Lambda Sgr. iii.
943	"	"	"	297.0	—35.0	5	G	G	"	— Sgr.
944	1935	July	3.67	312.3	—10.5	3/4	F	M	10.8	Tau 2 Cap.
945	1935	July	5.67	322.0	—17.5	3/4	F	M	12.8	Iota Aqr.
946	"	"	"	338.0	—61.0	4	G	M	"	
947	1935	July	6.59	284.0	—26.0	4	F	F	13.7	Psi Sgr. ii.
948	"	"	"	302.7	—10.5	5	G	F	"	— Aql (S.I.C. 237).
949	"	"	"	310.5	—4.5	3/4	G	F	"	? Alpha Cap. i.
950	"	"	"	336.0	—33.5	5	G	F	"	— PsA (S.I.C. 282).
951	1935	July	10.09	331.5	—32.5	7/9	G	M	17.6	Mu PsA.
952	1935	July	11.09	332.0	—31.5	12	G	M	18.6	Mu PsA.
953	1936	July	16.47	298.7	—24.2	5	G	F	23.9	53 Sgr.
954	1936	July	22.47	307.6	—30.0	4/6	G	G	29.8	? — Cap. (S.I.C. 250).
955	"	"	"	317.0	—23.0	4	G	G	"	Eta Cap.
956	1936	July	22.69	321.7	—4.3	4/5	G	M	30.0	— Aqr. (S.I.C. 262).
957	"	"	"	342.3	—32.4	5/6	G	M	"	Alpha PsA.
958	"	"	"	347.6	+ 4.0	3/4	F	M	"	D. 268, 5.
959	1936	July	23.67	23.0	—30.0	5/6	G	M	31.0	Inc. 1 meteor July 24.
960	"	"	"	267.0	—64.4	2/3	G	M	"	2 meteors close rad.
961	"	"	"	338.5	—32.0	0/7	G	M	"	3 meteors July 24. Beta
962	1936	July	24.67	33.8	+ 7.7	4	G	M	32.0	[PsA. ii.]
963	"	"	"	309.0	—9.5	3/4	G	M	"	Beta Cap. ii.
964	"	"	"	325.0	—24.0	3/4	P	M	"	— PsA. (S.I.C. 266).
965	"	"	"	330.0	—16.5	6/8	G	M	"	2 meteors July 23. Iota
966	"	"	"	338.4	—17.1	5/0	G	M	"	Delta Aqr. [Aqr. ii.]
967	"	"	"	351.5	—11.5	6/7	G	M	"	Beta Cet. iv.
968	1935	July	26.68	339.3	—17.3	9	G	M	33.0	Delta Aqr.
969	1935	July	27.66	311.5	—10.0	3/4	P	M	34.0	Beta Cap. ii.
970	"	"	"	340.0	—17.0	15	G	M	"	Delta Aqr.
971	1935	July	27.57	314.5	—20.5	4/5	G	F	33.9	Eta Cap.
972	"	"	"	337.0	—9.0	5	G	F	"	Doubtful. 70 Aqr.
973	"	"	"	342.7	—18.0	4	F	F	"	Delta Aqr.
974	"	"	"	343	—32	4/5	P	F	"	Diffuse. Alpha PsA.
975	1935	July	28.59	24	—65	4/5	F	G	34.9	
976	"	"	"	330.0	—19.5	6	G	G	"	Iota Aqr. ii.

No.	Date G.M.T.	Radiant.			Mets.	Wt.	Obs.		Remarks.
		R.A.	Dec.						
977	"	"	"	342.0	-17.0	12	P	G	" Diffuse. Delta Aqr.
978	"	"	"	343.0	-31.0	17	G	G	" Diffuse. Alpha PsA.
979	1936	July	28.67	15.0	-50.0	4/5	G	M	35.9
980	"	"	"	31.5	-49.5	3/4	F	M	"
981	"	"	"	319.8	-20.7	3/6	F	M	" Eta Cap.
982	"	"	"	339.0	-17.0	14	G	M	" Delta Aqr.
983	"	"	"	346.0	-58.0	7	F	M	" Gamma Tuc.
984	1935	July	30.55	343.5	-15.0	12	F	F	36.8 Diffuse. Delta Aqr.
985	1935	July	31.60	9.0	-19.0	5/7	F	G	37.9 Beta Cet. iii.
986	"	"	"	20.0	+ 5.0	5	G	G	" D. 19, 1.
987	"	"	"	33.0	-31.0	4	G	G	" — Phe (S.I.C. 22).
988	"	"	"	342.7	-15.5	20	G	G	" Delta Aqr.
989	"	"	"	344.0	-29.5	8	P	G	" Alpha PsA.
990	1935	July	31.67	34.0	- 2.5	6/8	G	M	37.9 75 Cet.
991	"	"	"	50.0	-34.0	4	F	M	" — For. (S.I.C. 36).
992	"	"	"	344.0	-15.0	6/8	G	M	" Delta Aqr.
993	"	"	"	352.0	-15.5	5	G	M	" Beta Cet. iv.
994	1935	Aug.	2.49	344.0	-15.0	4	P	F	39.7 ? Delta Aqr.
995	1935	Aug.	2.62	6.5	-19.5	7	P	G	39.8 Beta Cet. iii.
996	"	"	"	45.0	-69.0	8	G	G	"
997	"	"	"	324.0	-17.5	5/6	G	G	" Delta Cap.
998	"	"	"	343.5	-30.5	11	G	G	" Alpha PsA.
999	"	"	"	345.5	-15.0	24	G	G	" Delta Aqr.
1000	1935	Aug.	2.67	39.0	-17.5	4	P	M	39.9 Diffuse. Pi Cet.
1001	"	"	"	66.0	-30.0	3/4	P	M	" [Comet 1877. ii.
1002	"	"	"	303.0	-15.5	4	G	M	" ? Alpha Cap. ii.
1003	"	"	"	337.5	-29.0	5	F	M	" Diffuse. Alpha PsA.
1004	"	"	"	345.6	-15.0	8	G	M	" Delta Aqr.
1005	1935	Aug.	6.61	6.5	-28.5	5/6	G	G	43.7 Alpha Sci.
1006	"	"	"	28.0	-29.5	4	G	G	"
1007	"	"	"	332.0	-32.0	4/6	G	G	" ? Alpha PsA.
1008	"	"	"	351.0	- 4.5	4	G	G	" 14 Psc.
1009	1935	Aug.	30.59	13.5	- 9.5	4	G	F	67.1 1 meteor Aug. 31. 21 Cet.
1010	"	"	"	339.0	- 5.5	5	G	F	" Ditto. ? Zeta Aqr. ii.
1011	1935	Aug.	31.56	5.0	- 4.3	4	G	F	68.1 Cet.
1012	1935	Sept.	1-2c	13.5	- 9.5	5/6	G	F	69.6 21 Cet.
1013	"	"	"	16.5	-17.7	4	G	F	"
1014	"	"	"	27.0	- 5.0	7/8	G	F	"
1015	1936	Oct.	19.64	80.0	+17.5	3/4	F	M	116.9 D. 69, 11.
1016	"	"	"	91.5	+14.6	13	G	M	" Ori.
1017	"	"	"	97.0	+17.0	6	G	M	" D. 79, 6.
1018	1936	Oct.	20.63	92.6	+14.5	22	G	M	117.9 Ori.
1019	1935	Oct.	20.65	86.7	+15.0	5/6	G	M	117.1 Ori.
1020	1935	Nov.	20.57	132.0	-58.0	5/6	F	F	153.8
1021	1938	Dec.	17.54	97.0	+21.0	1	F	B	175.3 Stationary meteor.

In the "Remarks" column, D refers to Denning's *General Catalogue of Meteor Radiants*, the first figures to the group, the final ones to the radiant number; BAA to the radiants of the British Astronomical Association; numbers with the initials NZ prefixed refer to radiants in reports of the Meteor Section already published, while S.I.C. refers to centres of radiation published in the *Southern Index Catalogue*. In all cases where the radiants are named, other radiants have been found confirming those now published.

The Director wishes to express his thanks to all the observers mentioned in this and preceding reports, by whose assistance the Meteor Section has accumulated an important mass of data, and looks forward to their continued co-operation in the future.

Private Observatory,

1 Melford Street, Auckland, W.I.

1939, June 24.

## The Makara and Karori Valleys and Their Bearing Upon the Physiographic History of Wellington.

By MAXWELL GAGE, M.Sc.

[Read before the Wellington Branch, July 14, 1937; received by the Editor, September 9, 1939; issued separately, March, 1940.]

### INTRODUCTION.

THE valleys named in the title of this paper exhibit numerous and varied terrace features from which evidence is obtained of a series of changes of sea-level, and at least one instance of tilting or warping of the land-surface of the south-western Wellington district. In his first general account of the physiography of Wellington, Dr. C. A. Cotton (1912, pp. 250–51) described the terraces of the Makara Valley, and the present writer has carried the study of these forms southwards into the Karori system and to the south coast. The sequence of events as visualized by Cotton is applicable to the southern area with certain modifications.

#### *Note on the Rocks of the District.*

The basement rock consists of the characteristic greywacke-argillite association generally regarded as belonging to the Hokonui System (Benson, 1922, p. 1), overlain by alluvial deposits ranging in age possibly from late Pliocene to present day. Except for an enigmatic occurrence at Makara of a littoral type of sediment with poor marine fossils (see later), Cretaceous and Tertiary strata are entirely absent. Cotton believed it possible that the Wellington area and contiguous portions of the South Island may never have been submerged since the post-Hokonui movements.

### TERRACE FEATURES.

A most conspicuous feature of the middle reaches of the Makara Valley is the prominent set of alluvial terraces related to a base-level about 120 ft. to 140 ft. higher than present-day. In the neighbourhood of the junction of the Makara and Ohariu Streams only rather indistinct spur-shoulders are to be seen, but as we pass upstream, definite terraces appear at this level and increase in width until at the Makara Golf Course the present-day stream actually has its source upon the floor of the old valley, which continues with a broadly open cross-profile into the area drained by the modern Karori Stream. Upstream, the terraces again diminish rapidly in width, owing to lateral planation in the later cycle by the south-flowing Karori, disappearing finally near the confluence of the two branches of this stream. The last trace in this direction of features related to this 120 ft. base-level is probably represented by a curious rock-bench remnant some 230 ft. above the floor of the modern Karori Gorge at a point about 10 chains downstream from the junction. Its surface is rather irregular in longitudinal section, but it slopes evenly at

about 10 degrees towards the edge of a sheer drop to the modern valley floor, and evidently was sculptured by a near-source tributary of the once southwards-extended ancestor to the modern Makara.

The prominent Makara terraces increase in height above sea-level, although more slowly than the modern valley floor, until at the Golf Course they are at 300 ft. From this point southwards, however, they fall steadily and a short distance upstream from the confluence of the Karori branches are 100 ft. lower. It is difficult to see how the terraces which have been described could have originated otherwise than by the work of a stream flowing north-westwards, for the cross-profile of the older valley as a whole increases in width in this direction, ancient alluvium at the same time becoming more extensive until near the Ohariu junction, where recent lateral planation by the Makara and its tributaries tends to eliminate it. Loss of height of the terrace surface southwards from the Golf Course at the present Makara-Karori divide is ascribed to warping of the surface, which will be treated more fully later.

In the valley of the main branch of the Karori Stream, this system of terraces is represented by flanking deposits of alluvium in the vicinity of the Karori tram terminus. Near to its source, the modern stream appears to be flowing on the floor of a valley sculptured in an earlier cycle, as in the case of the Makara and Karori West Branch Streams, but as we pass downstream, it becomes rapidly entrenched to about 90 ft. at the end of the South Karori Road. At the same time it has carried on lateral planation sufficient to break up the alluvial terraces into discontinuous remnants and to eliminate them altogether beyond the end of the road. Downstream from here, the valley as a whole has become much narrower, a few spur-shoulders and a distinct change of slope of the hillside alone remaining until the junction with the West Branch is reached, but there is little doubt that these features correspond with the Makara terraces. In the lower reaches, the Karori is a strikingly youthful stream, its steep, unbroken valley-sides being devoid of high-level terraces, although raised marine platforms exist on the south coast.

In the Ohariu Valley, similar but less complete dissection of the prominent terraces was noted by Cotton (1912, p. 251). Except for a short gorge near the junction with the Makara, the modern stream is not deeply entrenched in the earlier flood-plain.

Indistinct higher terraces are visible near Karori Park, diminishing in relief northwards until their surface appears to merge into the floor of the important ancient valley system described by Cotton under the name of the "Long Valley." (1912, p. 262.)

The last system of terraces to be described is peculiar to the upper reaches of the Karori Stream and due to entrenchment, increasing downstream in both branches to a maximum of about 20 ft., below a sub-recent floodplain of moderate extent at the junction of the two main branches.

#### RAISED COASTAL BENCHES.

At Tongue Point, of the two distinct flights of elevated, wave-cut benches, the lower and more extensive was recognized by Dr. L. C. King (1930, pp. 500-2) as a continuation of a similar remnant at

Cape Terawhiti, increasing in altitude from 120 ft. there, to twice that figure at Tongue Point, and thence dipping steadily eastwards. East of Karori Stream both sets disappear, seemingly as a result of rapid coastal recession along a section of the coast where fault-crushed rocks favour wave-attack. Still farther east, resistant rock again occurs, but the benches do not reappear; their eastward inclination alone would be sufficient to have caused them to plunge beneath the sea and be masked by sediments near the entrance to Port Nicholson.

Meagre remnants of other elevated wave-cut platforms occur at Te Kaminaru Bay and at the southern extremity of Ohariu Bay, differing not greatly in height in either case from the Terawhiti platform. Elsewhere they appear to have been destroyed by vigorous cliff recession, which has also betrunked a former tributary of Makara Stream known as Smiths Gully.

#### PHYSIOGRAPHIC HISTORY.

Although Cotton (1916, p. 41) considered that the land to the north-west and to the south of the present Wellington Peninsula subsided beneath the sea, he did not attempt to fix the dates of the founderings. So great are the recognizable physiographic changes since this commencement of the evolution of the modern landscape, despite a preponderance of resistant rock, and so long the lapse of time involved that the writer feels justified in assuming the great subsidence to have taken place during a crisis of the Kaikoura Orogeny.

*The Kaukau Cycle.* The wide-open valleys and gentle relief of the earliest recognizable erosion cycle, the Kaukau Cycle of Cotton (1912, p. 248), were only in part controlled by structure at the close of the period. They might be termed sub-senile, and the rock beneath the old surface in the few places where exposed is very deeply weathered. In addition to Cotton's examples, other discontinuous fragments of the Kaukau surface exist on the ridge between Karori and Waiariki Streams, as well as on others nearby and on the divide between Island and Ohiro Bays, all at different heights above sea-level. A few eminences such as Mt. Hawkins, rising abruptly above the general level of the ridges and surface remnants must represent monadnocks of Kaukau times. In carrying out surface reconstructions based on present-day relations between fragmentary remains, it is fully realized that these may have been disturbed by deformational movements of which we have no knowledge. Nevertheless, from higher viewpoints indications can be seen of an ancient valley system, now occupied by the Makara and the Karori. A branch, separated from the main valley by the modern Makara ridge, is occupied by the east branch of the Karori. Northwards from Karori Park, traces of this branch of the Kaukau Cycle valley are indistinct, mainly owing to dissection by the "Long Valley" system.

The valleys of the Kaukau Cycle extended well beyond the present land, but it is difficult to tell in which direction the stream flowed in the ancestral Makara-Karori Valley, as the remaining traces may have been displaced by non-uniform earth movements. The lowest areas of the Kaukau surface are near the mouth of Makara

Stream, while in the South Karori district points which must have been near the middle of the old valley-floor are 200 ft. to 300 ft. higher. On the other hand, the manner in which the branch valley joins the main one suggests a direction of flow from north to south.

*Post-Kaukau Uplift.* The sub-senile land-mass was elevated about 600 ft., and immediately active degradation was resumed during a fairly long stillstand until the streams, following courses inherited from the previous cycle, became graded in their lower reaches with respect to a base-level not greatly different from that of to-day. Cotton, however, postulated a change of level equal only to the vertical interval between the Kaukau surfaces and those of his Tongue Point Cycle, represented by the major Makara terraces and the lower Tongue Point platform. The reasons for favouring the greater uplift involve consideration of the Makara fossils which will now be dealt with.

*The Makara Fossils.* Fragments of massive, marine, worn and broken oysters are contained in a fine conglomerate consisting of fairly well rounded greywacke and argillite debris in a sparse, muddy matrix which outcrops in a small branch of the Makara Stream. The deposit was first described by A. McKay (1877, p. 50), who considered it to be Miocene in age. F. K. Broadgate (1916, p. 78) thought that, on the physiographic evidence alone the beds could not be younger than Pliocene, and that they are a remnant of a once extensive Tertiary cover preserved from erosion locally at Makara by down-faulting; but he cited no facts in support of his contention.

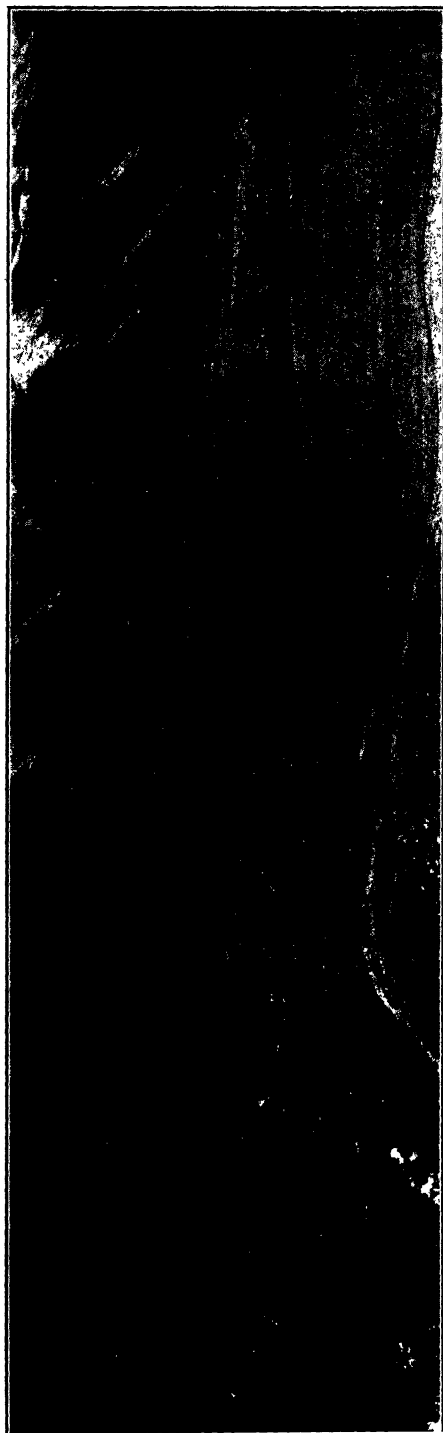
Dr. Marwick informed the writer that merely from the massive type of oyster that the indeterminable shell fragments represent, and from the degree of induration of the matrix, he would infer a probable Pliocene age for the deposit. Against Broadgate's faulting hypothesis is the absence of signs of the implied post-Pliocene faulting in the vicinity, although zones of intense faulting show in the greywacke nearby. It is unlikely that a portion of a widespread Tertiary cover has been preserved in a depression of the undersurface as other relics would surely have been found. The deposit is confined between fairly steep greywacke walls, but the actual contact with the basement rock is not exposed. A fossiliferous bed about 2 ft. thick underlies 6 ft. of barren conglomerate, while at another locality, 200 ft. distant across the valley, poorly rounded fine conglomerate indistinguishable from the barren layer merges upwards without visible break into consolidated gravels such as make up the bulk of the main Makara Valley terraces. Stratification is poor, but neither folding nor tilt were detected.

*Re-submergence.* The writer considers that the post-Kaukau Cycle elevation was sufficient to enable the sculpturing of youthful valley systems below the previous cycles to a lower level than the floor of the present Makara Valley, but that before much widening was effected a reversal of movement permitted estuarine waters to invade the land, the Makara shell-bed being deposited at the head of an estuary. Submergence continued, but was either intermittent or slower than the initial plunge, so that bay-head progradation was able



Tongue Point-Cycle Terraces in the Makara Valley.





Divide between Karori West Branch (left) and Makara Stream (right) on Tongue Point-Cycle flood-plain surface at Makara Golf Course.





FIG. 1.—Mature spurs carved from Tongue Point-Cycle valley-floor  
at Makara-Ohariu confluence.



FIG. 2.—Smiths Gully, shortened by cliff-recession under vigorous marine  
erosion, viewed from across Ohariu Bay.



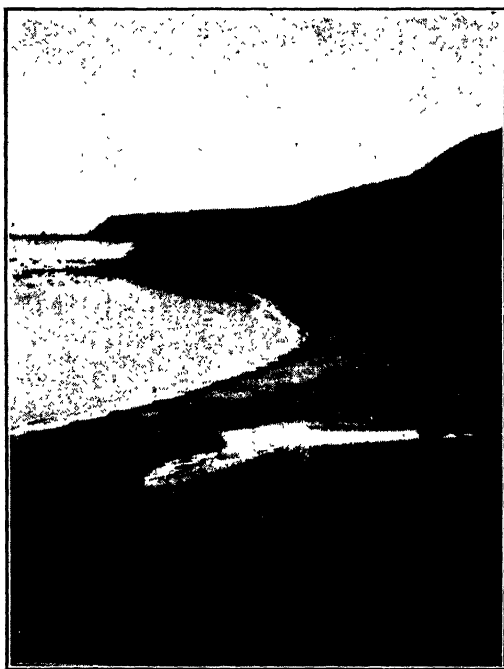


FIG. 1.—Mouth of Karori Stream and Tongue Point, showing elevated, wave-cut platform.

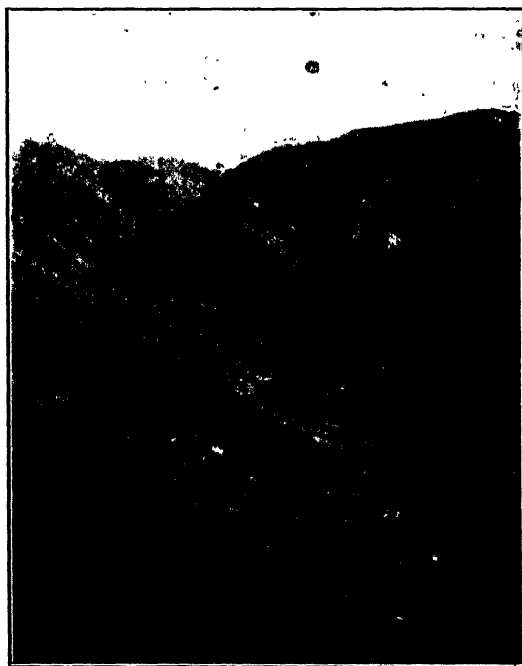


FIG. 2.—Lower reaches of Karori Stream. Compare width of flood-plain with middle reaches of Makara,





FIG. 1.—Gravel beds on valley-side, South Karori Road.

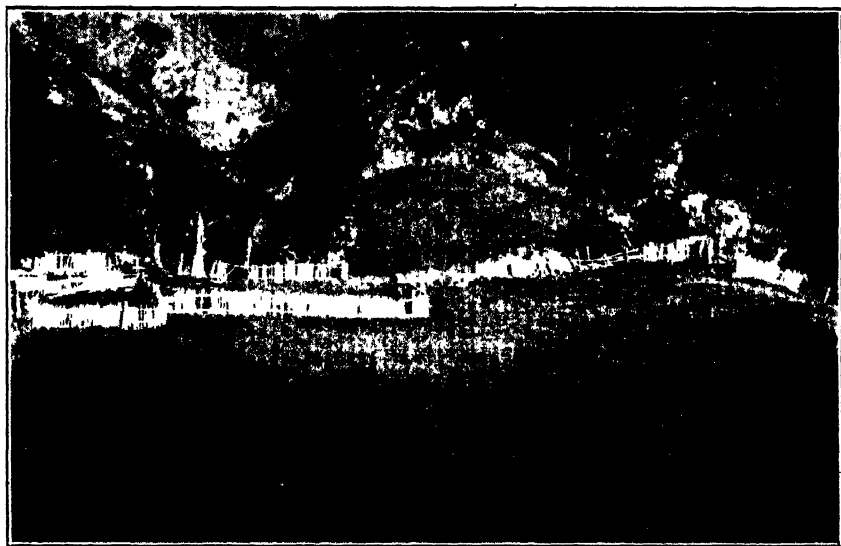


FIG. 2.—Surface of southernmost gravel terrace in Karori Valley,  
end of South Karori Road.



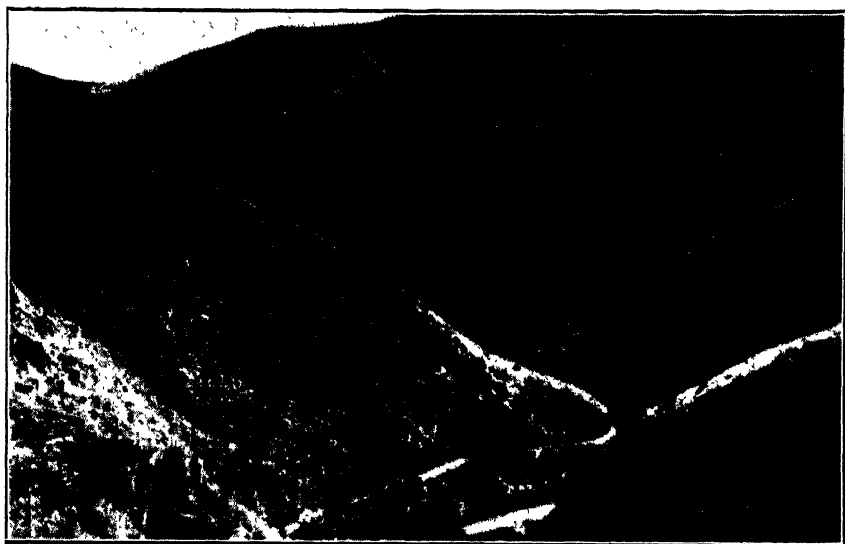


FIG. 1.—Spur-shoulders in Karori Valley downstream from terrace shown in plate 55, fig. 2.

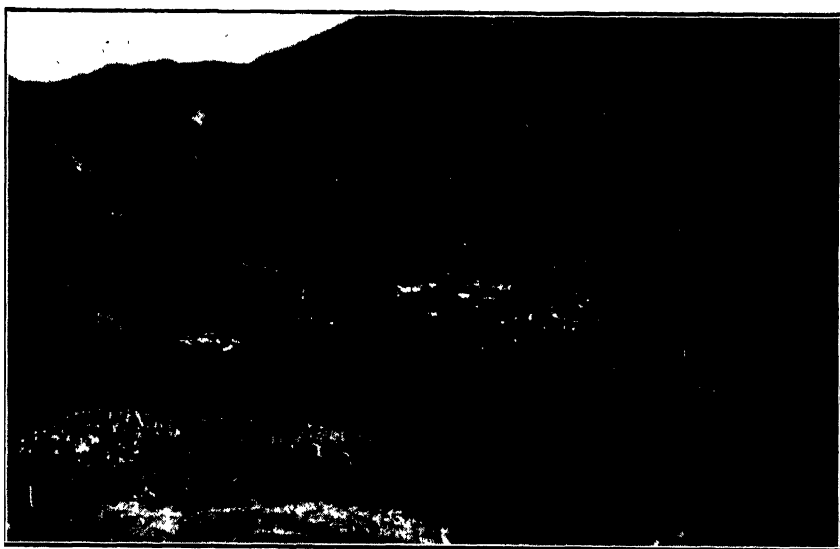


FIG. 2.—Entrenchment of modern Karori Stream, ascribed to acquisition of volume following on captures.



not only to maintain the shoreline, but evidently also to cause it to advance down the valley. Delta deposits and then flood-plain alluvium were laid down in turn over the littoral material, deepening as depression of the land continued, until base-level was raised to the level of the highest set of marine erosion benches on the south coast. Then occurred a pause long enough to allow of the sculpture of these features.

*The Tongue Point Cycle.* At the time of the above-mentioned pause, valleys carved earlier from the Kaukau surface were deeply filled with alluvium. This is the interpretation placed upon the terrace gravel deposits of the middle reaches of the Makara Valley, of the "Long Valley," and perhaps of Tinakori Valley, laid down in eroded depressions below the level of the Kaukau Cycle remnants, although the Tinakori example is obscured by the Wellington Fault. The nearby important valley system of the Hutt contains a great thickness of gravels which may have been deposited under similar circumstances. Following upon the stage of maximum submergence, a series of earth movements, probably with intervening halts, then brought sea-level to its present position. A major halt in uplift saw the formation of the wide, lower, wave-cut bench at Tongue Point, re-excavation of the Makara Valley, and its widening to a mature cross-profile with walls outside the ancient gravel-filled trough. If a Pliocene age may be accepted for the Makara material, it would follow from the above discussion that the Tongue Point period of erosion occurred since that time, but that the Kaukau Cycle is earlier.

*Makara—"Long Valley" Capture.* The high-level terrace remnants near Karori Park mark the most southerly traces of the floor of the "Long Valley" of Cotton. A south-westward flowing branch of the Makara River of Tongue Point times, as mentioned earlier, worked back northwards and captured the headwaters of the "Long Valley" which also then evidently possessed a widely flaring cross-profile, but was dominated over by its westerly neighbour, which probably had the advantage of a more direct course to the sea.

*Cook Strait Foundering.* A glance at the Admiralty chart of Cook Strait (N.Z. No. 695) shows extreme irregularity of the sea floor off the south Wellington coast, except where masked by sediments opposite the entrance to Port Nicholson and the Wairau River mouth, strongly suggested a drowned land surface (Cotton, 1918, p. 325). There is a rather abrupt change to shallower depths about the 50-fathom line, inshore from which is a more even submarine bench, free from sediments in many places, and ascribed to wave-planation acting at a depth somewhat greater than usual owing to the effect of strong tidal scour and the prevalent stormy conditions of the Strait preventing accumulations of protective debris. The line of sudden deepening is believed by the writer to mark approximately the position of a fracture separating the subsided from the upstanding block. The drowning occurred after the Kaukau Cycle, but necessarily before the uplift of land preceding the Tongue Point Cycle, to account for the raised wave-cut platforms. He favours a period co-eval with the sinking discussed in connection with the Makara

fossils, and considers that the subsidence of the southern block may have continued after the northern block halted, with dislocation along the fracture referred to, and that the submerged area did not take part in the subsequent rise of the peninsula. During each pause in uplift, the coast has receded from the fracture under wave-attack. To-day recession is proceeding rapidly, and the smaller streams flowing to the south coast cannot cut down rapidly enough, reaching the shore in cascades.

Cotton considered (1912, p. 254) that the west coast of the peninsula also is derived from an initial fault coast. It is thought, from the relatively more advanced development of the streams flowing to the west coast compared with those flowing to the south, and from the more mature condition of the west coast, that the foundering of land to the west occurred at a more distant date.\*

*Karori-Makara Capture.* Following on the formation of a new south coast much farther north, rapid south-flowing torrents dissected the older valley-floors, steadily pushing the divides northwards. These streams had the benefit of a short steep course to the new coast, and more rapidly experienced the advantages of recurrent uplifts of the land; so it is not surprising that the largest and most successful of them, the Karori, should in time break through into the Makara system, and effect an important capture. One by one the headward tributaries of the Makara were diverted to the south coast, and finally the important branch that effected the "Long Valley" capture was claimed, giving rise to the Karori Stream as we now know it, flowing in a deep valley far below the remaining traces of the earlier Makara southward extension.

A western tributary of the Karori became established in the main Makara Valley, causing the migration of the divide farther northwards, and the formation of the higher set of terraces south of the Makara Golf Course, the terraces along the South Karori road, and the change of slope of the walls of the narrow upper Karori Valley.

*Post-Tongue Point Uplift and the Port Nicholson Subsidence.* King (1930, p. 502) could not make out whether a uniform uplift terminated the Tongue Point Cycle, followed by a later deformation that tilted the coastal platforms and Makara terraces. It seems logical to associate these tiltings with the movement that depressed beneath the sea the Port Nicholson area (Cotton, 1912, pp. 250-4) as phases of the same disturbance. The effects would be produced by a rotation about a north-north-east axis a little east of Karori Stream, lowering to the east and elevating to the west.

The Karori Stream had no extensive floodplains such as would leave terraces to bear witness to the uplift in the lower reaches. The western tributary dissecting the Makara Valley had its gradient increased by the warping. The main stream would have been hindered as it flowed obliquely up the dip of the warp, but its steep gradient coupled with rejuvenation must have offset the adverse effects. Cotton

\* Dr. L. C. King's paper (*Trans. Roy. Soc. N.Z.*, vol. 68, pp. 544-569) on the origin of Cook Strait had not appeared when this paper was read.

(1912, p. 264) has described captures of portions of the "Long Valley" system by the Kaiwarra and Ngahauranga, vigorous new streams flowing down the tilted surface into Port Nicholson, and their subsequent rejuvenation through the formation of the Wellington fault, across which they flowed towards the downthrown side.

Another effect of the warping was the immediate diversion of all the water of the Makara Valley from as far north as the present divide at the Golf Course into the Karori system. This may in part account for the present entrenchment of as much as 20 ft. at the junction of the Karori branches, but in all probability the chief cause of this was cutting down of the west branch necessary to maintain an accordant confluence with the main branch, which had been further rejuvenated by another capture to be described.

*Silver Stream and Kaiwarra Captures.* The Silver Stream, an insequent tributary of the Karori, tapped the headwaters of an earlier high-level stream which followed the shatter-belt of an ancient fault. This may have been part of a lost stream of the Hutt system whose course is now indicated by gravel and silt beds on the east side of Tinakori Valley, as described by Cotton (1912, p. 258). The increased flow of water following upon this capture is believed to be the cause of entrenchment of the Karori.

The portion of the old valley below the elbow of capture of the Silver Stream has been added as a result of the Kaiwarra capture to the Kaiwarra system (Cotton, 1912, p. 262).

*The Uplift of 1855.* The writer has little to add to the account of the raised beaches given by Bell (1909, p. 538). It was noted, however, that there are numerous breaks in the continuity of these features, as for example between the Karori mouth and Tongue Point, due either to subsequent removal of the material by the waves, or to the fact that prior to the uplift, the waves at high tide may have reached to the base of the cliffs, preventing the building of the characteristic storm beach.

#### ADJUSTMENT TO STRUCTURE.

The Wellington Peninsula may be regarded as consisting of north-north-east-striking belts of resistant rock alternating with weak zones of fault-crushed material. The zig-zag pattern of the modern streams reveals the influence of these structures upon their courses. Short, gorgy, transgressive reaches are characteristically joined by lengths of wider valley with more open cross-profiles, more or less parallel with the general strike-direction of the rocks. A similar tendency is exhibited by the Tongue Point Cycle forms in the Makara Valley. Again, the Waiariki Stream passes from one weak belt to the next through narrow transgressive water-gaps. The general obliquity to structure of the Makara-Karori lineament as a whole, however, is ascribable to the controlling influence of an ancient valley of an earlier cycle of erosion, within the limits of which it lies. The question then arises as to why this ancient valley disregarded the structural trends. Superposition may be eliminated, as there is no evidence for a stripped Cretaceous or Tertiary cover. We are left with the

remaining alternative suggestion that the common tendency in sub-senile phases toward widespread lateral planation and consequent destruction of earlier adjustment to structure was in this case promoted during the Kaukau period by the upsetting of gradients through a diastrophic movement.

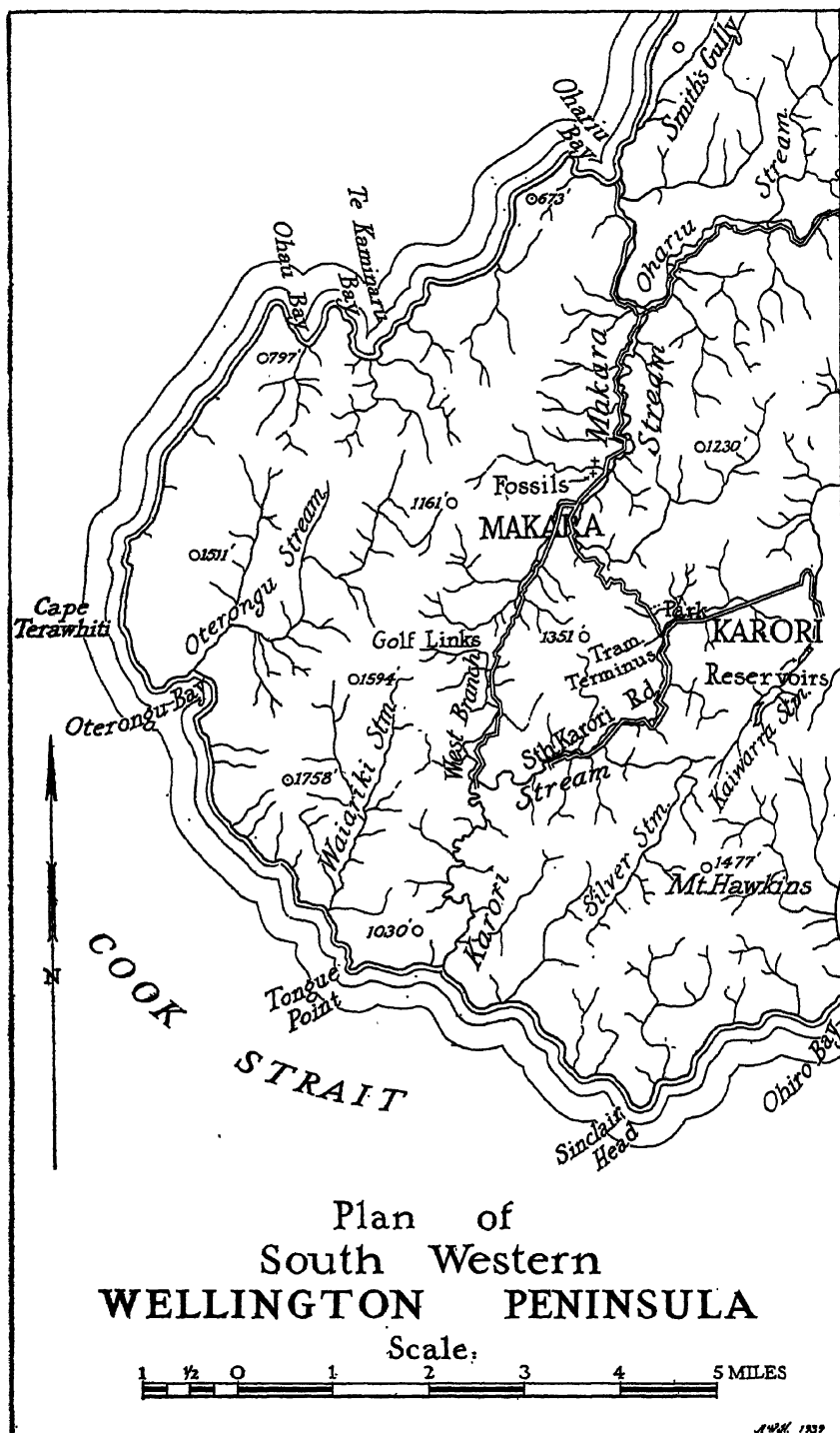
The crooked course of the Karori is no doubt largely due to its being made up of a number of sections of different streams connected by a succession of captures.

#### ACKNOWLEDGMENT.

Before concluding, the writer wishes to express his thanks to Mr. A. W. Hampton, who re-drew the locality plan for reproduction.

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## The Validity of the Coccid Genus *Eulecanium* Cockerell.

By G. BRITTIN.

[Read before the Canterbury Branch, March 29, 1939; received by the Editor, April 26, 1939; issued separately, March, 1940.]

IN the *Canadian Entomologist* of February, 1901, T. D. A. Cockerell and P. J. Parrot give a table for the separation of the genera of Coccidae related to *Lecanium* Burmeister, a continuation of a former table published in the same journal in November, 1899. Among the genera and subgenera mentioned is that of *Eulecanium* Ckll., which is defined as follows:—

2. Female convex, usually hemispherical, hard when mature, legs and antenna slender, normal. . . 6
6. Skin microscopically tessellated, holoarctic group. *Eulecanium* Cockerell.  
Skin with polygonal areas containing pits. . . . *Saissetia* Deplanches.

Cockerell's paper wherein he erects the genus *Eulecanium* has not been available, but Green (1904), in a supplementary note, states that the type of *Eulecanium* Ckll. is *E. tiliae* (Linn.), a species with which I am unacquainted.

Harry F. Dietz and Harold Morrison (1916) do not recognise the genus *Eulecanium*, but mention it as a synonym of the genus *Lecanium* Burm., which they diagnose as follows: "Female circular to oval, legs and antenna fairly well developed; middle spiracular spine less than twice as long as the outer two (except *nigrofasciatum*); anal ring with eight hairs; hypopigial setae wanting." They then proceed to describe six species, and in each the genus *Eulecanium* is placed as a synonym.

Green (1904), in a supplementary note, gives a list of subgenera not yet represented in Ceylon, among which is found the genus *Eulecanium* Ckll. On going through his species, however, I find two placed in the genus *Saissetia* which have certain characters found only in the genus *Eulecanium*. When giving an annotated list of the Coccidae of Ceylon, Green (1937) further states as follows: "The genus *Lecanium* itself has been split up and disguised under a multitude of names, some of which I have indicated in brackets. But the boundaries of most of the proposed genera are so indeterminate that it is difficult to assign a species to one or other of them with certainty. The only genus (or subgenus) that is unmistakable is *Paralecanium*, which is distinguished by a marginal fringe of flabelliform setae."

It has long been obvious to all who make a study of the Coccidae that the old genus *Lecanium* has become unwieldy, and, as stated above, the proposed genera are by no means helpful. This fact has been particularly evident to me for the last few months, during which time I have been making a systematic study of the life-history of *Lecanium persicae* (Fab.).

In the adult instar, owing to the character of the stigmatic spines, this species could not be mistaken for any belonging to either of the genera *Coccus* or *Saissetia*. In the larval instar also it differs in the

same way from the species in those two genera. It is in the intermediate instars that difficulty in identification arises, for the insects are then flat, soft, and the stigmatic spines are similar to those of insects of the same stage in both those genera.

Cockerell (1901), in his diagnosis of *Calymnatus* (= *Coccus*), states as follows:—

- |  |   |                           |
|--|---|---------------------------|
| 1. Female flat or slightly convex, legs and antenna slender, normal. . . . . | 5 |                           |
| 5. Female with marginal hairs, body soft, moderately convex. . . . .         |   | <i>Calymnatus</i> Costa.  |
| Female with marginal hairs, skin hard, with large tessellations. . . . .     |   | <i>Eucalymnatus</i> Ckll. |

On comparing the diagnosis of *Calymnatus* with that given for *Eulecanium*, the only distinct difference between the two genera is found to be in the derm of the latter being hard when mature, and microscopically tessellated. One can distinguish between flat and hemispherical, but intelligently to convey the distinction of convex and slightly convex is an entirely different matter; moreover, marginal hairs are present in all the species, and with the exception of the genus mentioned by Green, vary according to the species and not the genus. Even the question of hardness is likely to become a matter of opinion, for it is not until the insect has deposited its eggs that the body becomes hard. There is, again, the tessellation of the dorsal derm, which is apparent only in the natural state, and quite disappears when the insect has been prepared and mounted. As to the number of hairs in the anal ring which, according to the diagnosis of the genus *Lecanium* given by Dietz and Morrison, are eight in number, these will be found to vary according to the species and not the genus; for while *Lecanium* (*Eulecanium*) *corni* Bouche certainly possesses eight hairs, *persicae*, which is undoubtedly congeneric with that species has only six, a fact which makes me doubt whether Marchal's (1908) description of the second instar of *L. corni*, which he states has six hairs on the anal ring, really belongs to that species.

There are only two species in New Zealand—so far as is known—that sometime or other have been placed in the genus *Eulecanium*, and they are: *E. persicae* (Fab.) and *E. corni* Bouche, with both of which I am acquainted. When these two were compared with descriptions of species belonging to many other genera, they were found to possess in common two characters which were never found together in any of the other genera, with the exception of a few species belonging to the old genus *Lecanium*. These two characters are: the long, subequal, stigmatic spines, and the punctate appearance of the dorsal derm. One or other of these characters may be found in other genera, but not the two together. As to the question of convexity of the dorsum, this is often increased or diminished according to the position the insect has taken up, and the question of size is equally valueless.

The punctate appearance of the dorsal derm is very distinctive in the mature adults, and is quite distinct from that found in the genus *Saissetia*. Some few species belonging to the genus *Coccus* are said also to exhibit this character, but the long stigmatic spines of *Eulecanium* are absent.

With the exception of Marchal's paper, no mention has been made as to the arrangement of the large multilocular pores found on the ventral surface of the abdomen. I believe these pores to be present in most genera belonging to the Coccinae. They appear to be analogous to those found in the Pseudococcinae and are a sign of maturity. In certain New Zealand species belonging to the genera *Ctenochiton* Maskell and *Inglisia* Maskell, it may be possible to use these pores in the separation of the genera, but until further investigations have been made into numerous species belonging to the genera *Coccus*, *Lecanium*, *Eulecanium*, and *Saissetia*, they will be of specific value only.

Taking into account all the known characters above mentioned, there is no reason why a workable system for the separation of the species under the different genera should not become available, and I beg here to give a generic diagnosis that will definitely place a number of species in *Eulecanium* as a subgenus of *Lecanium* Burmister.

#### Subgenus EULECANIUM Ckll.

Adult females after ovipositing, convex, sometimes hemispherical, dorsum more or less chitinised, usually hard, with numerous small clear areas, round or oval, giving to the body a punctate appearance. Legs and antenna normal, usually slender; stigmatic spines in triplicate, all three long and sub-equal; submarginal tubercules present or absent; small tubular ducts usually present in submarginal bands on ventral surface; large multilocular disc pores present on ventral surface of abdomen; ventral derm spines present or absent; anal complex of normal lecanid form; anal cleft usually well-developed, open. Larva normal, with three very short sub-equal stigmatic spines. Intermediate instars with the central stigmatic spines much the longest.

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## The Life History of *Lecanium* (*Eulecanium*) *persicae* (Fabricius), and Descriptions of the Different Instars.

By G. BRITTIN.

[Read before the Canterbury Branch, March 29, 1939; received by the Editor, April 26, 1939; issued separately, March, 1940.]

THERE are found in New Zealand some Coccidae belonging to the sub-family Coccinae which, in their natural state, and also when examined microscopically, are very similar in appearance. These apparent species, or varieties—whichever one may prefer to call them—have for many years puzzled students of this group, so much so, in fact, that at the present time no one appears willing to identify them positively, but all prefer to place them in what is usually called the "*persicae*" group. There are quite good reasons for this procedure, seeing that the original description of *L. persicae* dates back as far as 1762 or 1766. According to Newstead (1902), the author of the name was Geoffroy, in 1762, but Marchal (1908), on the other hand, gives the credit to Fabricius in 1766, in which he is followed by Green (1930). Seeing that there is a doubt about the name of the author, it is little wonder that there has long been a doubt about the identity of the species, and that the list of synonyms is somewhat longer than usual, and that no two lists should be the same.

Still further to complicate the matter, Douglas (1885) confused *L. persicae* with at least two quite distinct species, i.e., *L. corni* Bouche and *L. coryli* Linn. This mis-identification by Douglas was later carried on by Newstead and Green in various publications on the British Coccidae. Marchal (1908) was the first to give a good definition of the species, and pointed out the mistake of Douglas, and his finding was later confirmed by Green (1930), who gave a diagram showing the important distinctions between *L. corni* Bouche and *L. coryli* (Linn.), showing clearly that they should by no means be confused with *L. persicae* (Fab.) when examined microscopically. Green also stated that the latter species was not indigenous to the British Isles, nor had it up to then been recorded as an introduced pest in greenhouses.

From time to time I have collected exotic species of Coccinae, but till within the last two years had never made any systematic study of them. Towards the end of 1937 there were found on the common broom plant in Motueka numerous specimens that did not agree with others under the same name in my collection, which had been identified by Mr. Green. As the literature available on this subject was limited, it was thought best to send out specimens to other students, which was accordingly done, specimens being sent to both U.S.A. and Italy. Up to the present time, the only replies received have come from the Entomological Department at Washington, U.S.A., where Mr Harold Morrison has identified specimens as belonging to the "*persicae*" group. Owing to the confusion that at present exists

in this group, he did not care to go further in the matter and make a more definite statement. In the meantime, I had gone on studying the species, collecting specimens from a large number of plants, preparing and examining them in all the stages that could be procured. Green (1929) had already reported the species as occurring on grape vines from Whangarei, and specimens were collected on grape vines from two different places in Motueka. These, on examination, appeared to show two different varieties, neither of which agreed with specimens collected on *Wistaria* at Ngatea, in the North Island. This appeared to be undoubted evidence of more than one variety of the species in this country, and it became difficult to know which of them was likely to be the species indicated by Fabricius. Green (1929) had simply mentioned the fact that the species was present in New Zealand, and in 1930 had merely stated that both he and Newstead were mistaken in the identification of *L. persicae* in England. It was not until Marchal's concise work on the subject became available later on that it was possible to identify what I now believe to be typical specimens of *L. persicae*. Though Marchal evidently made a very close study of this species, he makes no mention of any variation. This may be accounted for by the fact that he did not always make a close microscopic examination of the specimens collected, but sometimes relied on their appearance in the natural state. As the insects under these conditions vary only slightly in colour, he may have overlooked differences.

Given the fact that Marchal's description of *L. persicae* was correct, there was little doubt that some of those collected on grape vines were typical specimens (and the same may be said of certain specimens collected from plum, honeysuckle, and gooseberry), but that other specimens collected from broom, *Pittosporum*, *Wistaria*, and other plants of grape-vine and plum in Motueka were a variation from the typical species. The specimens collected on *Wistaria* at Ngatea were distinct again from either of the others above mentioned. The fact became evident after the examination of a large number of specimens taken from different kinds of plants, that they could not possibly be what is called "host variations," and the matter became still more complicated later on when young insects were examined as they became available, for not the slightest difference could be distinguished between them. There is no doubt about the species being exotic and, as rather a long list of synonyms is attached to the specific name, there will always remain a probability of any variety having been already described under one or other of the many names attached to the species in the past. The possibility, however, of any such proof being given is very remote. In the early days of their study, the description of these insects was almost wholly confined to their appearance in the natural state, when colour, size, shape, habitat, together with a very short description of the antennae, was thought to be quite sufficient. The usual method of preparation in those days was that of clearing in oil, and as staining was out of the question, many of the finer characters—such as minute pores and spines—would be practically invisible. This makes it extremely doubtful that even if the original specimens were examined, their identity with those

now living could be confirmed. Under these circumstances, and in the light of our present knowledge of the species, it has been thought best to attach a name to any variation from the typical that gives every indication of being permanent.

Marchal undoubtedly made a very close study of several species that have been placed in this subgenus, and gives a very good description of all the supposed instars, with the exception of the larval instar of *L. corni* Bouche. From observations made during the last fifteen months, there is little doubt that Marchal's second instar of *L. corni* is really that of *L. persicae*, while his second instar of *L. persicae* should have been the third instar of that species. After all, it is not surprising that such a mistake should have occurred, when we consider that both species are very prevalent in Europe, and are often found together on the same plants, for under such circumstances it would be very hard to distinguish between the intermediate instars of the different species. One of the most important differences between the two species when in the adult instar is the presence of submarginal tubercles in *L. persicae*, and their entire absence in *L. corni*. The real function of the submarginal tubercles is as yet obscure, but from each there is exuded a long waxy thread that is more apparent in the young insects than in the adults. Whether or not these tubercles are present in the intermediate instars of *L. corni* I cannot affirm, owing to these instars not being available in my collection, but judging from what is known of other species, there seems to be no reason why they should be. One fact that many enlighten us as to the identity of typical *persicae* is that Marchal (1908, p. 290), in referring to the submarginal tubercles, states as follows: "Elles sont de chaque côté au nombre de 5 à 6 avant la première échancrure stigmatique; 2 entre les 2 échancrures stigmatiques; 7 (parfois 6) entre l'échancrure stigmatique postérieure et la fonte anale soit donc une trentaine sur toute la périphérie. Leur nombre d'ailleurs est variable, mais dans des limites d'une très faible étendue; on peut parfois trouver 14 glandes d'un côté et 15 glandes de l'autre sur le même individu."

There is little doubt that this information as to the submarginal tubercles is important when taken in conjunction with an eight-jointed antenna. With 14 to 15 tubercles on each side, this would mean from 28 to 30 tubercles for the insect; moreover—and this will be very important to remember when we refer to the descriptions of the different variations found in New Zealand—there are two tubercles on each side between the anterior and posterior stigmatic areas. Judging from this, one would be apt to believe that if certain specimens are found in New Zealand with a seven-jointed antenna, with not more than half the number of tubercles—and with only a single tubercle between the two stigmatic areas—they certainly do not agree with the description of *L. persicae* given by Marchal, and, unless good proof to the contrary is given, should be placed as a distinct species.

Marchal is very positive as to the eight-jointed antenna of *L. persicae*, for he states as follows: "Antenne (fig. 34). Assez longue, grêle, de 8 articles (et non de 7 comme chez *L. corni*)."

is clear proof that he had not then found any specimen with a seven-jointed antenna. He also makes no mention of the stout conical spines in *L. persicae*, and this is an oversight that is hard to understand seeing that he draws attention to the very minute ones found on the derm of *L. corni*.

Regarding the size of the insects, one must allow for a great deal of variation in the adults. The greatest variation that has yet come to my knowledge is from 4 mm. to 9 mm. in old adults taken from the same plum tree. This is well worth bearing in mind, for in the past the question of size alone has apparently been used in the separation of the species. Both colour and shape are just as useless as size, and the only safe guides are the various pores, glands, and spines found on both the dorsal and ventral surfaces of the body. The antennae are, to a certain extent, useful, but too much reliance should not be placed on them unless supported by other characters. The legs are quite useless, but the plates of the anal complex must be considered as one of the best and most consistent guides to classification owing to the fact that they vary so little during the whole life of the insect, from the second instar to the adult.

#### LIFE HISTORY.

In spite of the long time that this species has been known to science, its life history has not, up till now, been fully worked out, as discovered from observations made during the last fifteen months. By some mischance, Marchal appears to have mistaken the second instar, which is not surprising when we consider the size of the insects and the difficulty one has in finding the larvae once they have spread. The growth of the insects during the first three instars is very slow, and it is not until after the third moult in the spring that much change in size takes place. Before the first moult the submarginal tubercules are absent, their place being taken by a double row of ten 8-shaped pores on the dorsum, which extends submedially from the anal complex to the thoracic segment. A side view of these pores shows them as very small twin projections of the derm.

The larvae first make their appearance about the middle of December, and immediately spread over the plant, usually making their way to the tender young shoots, or, in the case of the grapevine, beneath the loose bark of the older limbs. Having fixed their location, they insert the rostral setae and remain fixed until the first moult occurs about the middle of February. Characters worth noting in the larvae are the 8-shaped pores and the very short, subequal, stigmatic spines.

The first moult having taken place, the 8-shaped pores are found to have disappeared, the plates of the anal complex have lost the very long stout seta, the middle stigmatic spine has become much longer, and what are known as the submarginal tubercules have made their appearance, there being four pairs. The anal cleft has become much more prominent, and now extends well below the anal plates. The antenna, however, still remains six-jointed as in the larva, but the tarsus is now slightly shorter than the tibia.

About the middle of April, the second moult takes place, and there has now been added another joint to the antenna, making it seven-jointed, there has been a slight increase in the length of the tibia, although actually the legs remain about the same size, and the number of submarginal tubercles is doubled. Apart from these slight changes, there is no appreciable alteration except a very slight increase in size.

One lucky enough to prepare specimens just before the moult takes place can observe several facts worthy of notice. The new skin—together with the marginal setae and stigmatic spines—is seen to be fully formed before such parts as the legs, antennae, anal complex, and submarginal tubercles. All these latter are seen to be still in a soft state, which is still further exemplified by the way they take the stain. Another fact is that the rostrum is cast off entire, together with the rostral setae, and the new setae can be seen neatly coiled up on each side of the new rostrum. It may also be observed that the submarginal tubercles are developed in quite a different place from where they are in the previous instar.

For the next seven months very little alteration takes place, even in size, until about the second week in October, when the first adults make their appearance, and it is easy to recognise those that have just moulted by the presence of a little white pellet above the anal complex. The stigmatic spines are now very much longer, and are again subequal; the submarginal tubercles have again nearly doubled in number; in typical specimens another joint has been added to the antenna, and six transverse bands of large multilocular pores have made their appearance on the ventral surface between the anal complex and the posterior pair of legs, with a group of similar pores near to the coxae of the anterior and middle pairs of legs. For some reason, probably climatic, the antenna and the submarginal tubercles may remain as in the pre-adult instar, but in such instances the multilocular pores are always present, and as stated before, these pores can always be looked on as signs of sexual maturity. After the last moult, the insects increase rapidly in size, and when egg-laying begins, become more and more convex, while at the same time the derm assumes a darker hue, and becomes quite hard, with a slight longitudinal carina. About the end of November, egg-laying commences, and at the end of December the first of the young larvae will have made their appearance. The times given here are approximate only, as it has been noticed that the time of moulting, egg-laying, or hatching of the eggs may extend over a period of at least a month, but in this district, at least, there is only one generation a year.

A description of the various instars and varieties of *L. persicae* found in this country follows:—

#### **Lecanium (Eulecanium) persicae** (Fabricius).

*Coccus persicae* Fab., *Gens. Ins. Mani.*, 1766, p. 304.

*Lecanium persicae* (Fab.), Marchal, *Soc. Ent. de France*, vol. 77, 1908, p. 285.

*Larva.* Emerges end of December. Antenna of six joints, last joint slightly longer than the third, formula: 6, 3, 5 (1, 2, 4). Rostrum and mentum normal. Legs normal, rather stout, tibia and

tarsus about equal. Spiracles normal, placed close to the margin, with which they are connected by a row of three small quinquelocular pores; stigmatic spines in triplicate, very short, subequal. Plates of anal complex roughly triangular, appearing in mounted specimens to be divergent, and not extending beyond the posterior margin of the body; with one very long seta at apex and another very short one on each side of it. The usual three pairs of stout setae on the ventral surface above the anal complex. Marginal setae present, simple, longest and stoutest at either extremity. Submarginal tubercles not recognised. Tubular ducts not observed. On the dorsum there are two submedian longitudinal rows of what look like 8-shaped pores; these are very small, and each row extends from the anal complex to just above the rostrum, when the insect has been flattened on the slide. A side view of these pores shows them like very small twin projections of the derm. There are ten in each row. Length of insect, 0.34 mm.; width, 0.18 mm.

Larva moult middle of February.

*Female of Second Instar.* Elongate, not chitinised, flat. Antenna of six joints, third joint longest, formula: 3, 6, 2 (1, 5) 4. Rostrum and mentum normal. Spiracles normal, connected with the margin by a single row of quinquelocular pores; stigmatic spines in triplicate, the middle one being much the longest and thickest. Legs normal, very stout. tibia slightly longer than tarsus; one digitule of claw thicker than the other. Anal cleft moderately deep, open. Eight submarginal tubercles, two on each side behind the posterior spiracles, one on each side between the anterior and posterior spiracles, and a pair above the anterior spiracles near the antennae. Plates of anal complex roughly triangular, set close together; inner margin longest, straight, base shortest and slightly concave, outer margin convex, apex rounded, with three small setae at apex and another in an indentation on the inner margin. There are about four fairly long and stout setae at the margin of the vellum, and three pairs of long stout anal-ring setae. The usual three pairs of stout setae on the ventral surface above anal complex, and, on a level with the middle pair, there is a transverse row of five minute spines. A sparse submarginal band of small tubular ducts round body. Marginal setae present, simple. Length about 1.04 mm.; width about 0.37 mm.

Second moult middle of April.

*Female of Third Instar.* Elongate, flat, soft, not chitinised. Antenna of seven joints, third joint longest, formula: 3, 4, 7, 2, 1 (5, 6). Rostrum and mentum normal. Spiracles normal, connected with the margin by an irregular row of quinquelocular pores; stigmatic spines in triplicate the centre one being much the longest and thickest. Legs normal, stout, tibia one-third longer than tarsus; one digitule of claw thicker than the other. Anal cleft open. Plates of anal complex roughly triangular: inner margin longest, straight, with a single indentation towards apex; base shortest, straight or slightly concave; outer margin convex, apex rounded; with one fine seta near outer margin and about three more at apex. With from fifteen to seventeen

submarginal tubercules on the dorsal surface arranged as follows: three to five on each side behind posterior stigmatic area; one between anterior and posterior stigmatic areas; four to seven in half circle above anterior stigmatic areas. Marginal setae present, similar to those of the previous instar. The usual three pairs of setae above the anal complex, and on a level with the middle pair there are five very minute spines in a transverse row, the two outer ones being in pairs, with a wider interval separating each pair from the centre one. Length about 1.10 to 1.48 mm.; width about 0.60 mm. to 0.82 mm.

Third moult about 15th October.

*Early Adult Female.* Ovate, flat or slightly convex, soft, with a somewhat wavy outline. Antenna of eight joints, third joint longest; formula: 3, 4, 5, 2, 8, 1 (6, 7). Rostrum normal. Spiracles normal, with a broad band of quinquelocular pores connecting with the margin; stigmatic spines in triplicate, long, subequal in length, the centre one being slightly thicker than the others. Legs normal, slender, tibia two-thirds longer than tarsus. Marginal setae differing in length and thickness, about three on each side of anal cleft being very thick; with an inner row of very short fine setae. Anal cleft not fused, but with the margins sometimes overlapping. Plates of anal complex roughly triangular: in typical specimens the inner margin is longest with two indentations, in each of which there is a stout seta; base shortest, straight or slightly concave; outer margin convex, and apex rounded with three short setae. In abnormal specimens in which the antenna is seven-jointed and with about sixteen submarginal tubercules, the anal plates are similar to those of the previous instar. Ventral surface with the usual three pairs of stout setae above anal complex. A broad band of multilocular pores surrounds the anal complex, with six transverse bands above, the uppermost being between the hind pair of legs; a loose scattered group of pores near to the coxae of the anterior and middle pair of legs. A broad submarginal band of tubular ducts is on the ventral surface. Two longitudinal rows of stout spines, submedian, on the ventral surface, and a few more scattered indiscriminately. Dorsally, a submarginal row of large tubercules is arranged as follows: seven to nine on each side behind the posterior stigmatic area: two—sometimes three—between the anterior and posterior stigmatic areas; nine to eleven in a half circle above anterior stigmatic areas. Two very stout and three fine setae near inner base of each antenna. Length of early adults 2.34 mm. to 4.40 mm.; width about 1.87 mm. to 2.88 mm.

*Old Adult Female (Typical).* With dorsal derm deeply chitinated, hard, convex, with a distinct longitudinal median carina. Antenna of eight joints, third joint longest, formula: 3, 4, 5, 2, 8, 1 (6, 7). Spiracles normal, connected with the margin by a broad band of quinquelocular pores. Stigmatic spines in triplicate, long, subequal. Legs normal, slender, tibia much longer than tarsus. Anal complex normal. A broad submarginal band of tubular ducts on ventral surface, also derm spines and large multilocular pores, but full particulars not obtainable owing to dense chitin of the dorsum.

Dorsum with numerous small clear areas of cells, giving the derm a punctate appearance; these are most numerous towards the margin of the body and sparse in the centre; the cells surrounding the anal complex and along the margin of the cleft are oblong and larger. Submarginal tubercules present on dorsum as in early adult. Length 4.65 mm. to 9.20 mm.; width about 3.50 mm. to 6.28 mm.

A variation sometimes found is where the adult female remains as in the third instar, the derm becomes convex and deeply chitinated, the same punctate appearance is to be seen as occurs in typical specimens, and the large multilocular pores are also present, showing that the insects are sexually mature. Such females do not appear to reach the large size found in typical specimens.

Hab.: On grape, broom, honeysuckle, plum, gooseberry, hawthorn, tree lucerne, lemon, *Pittosporum* sp., *Aristotelia* sp., *Wistaria* sp., Motueka, N.Z.

***Lecanium (Eulecanium) persicae* (Fab.) spinosum** n.subsp.

Early adult female. Elongate-ovate, with a wavy outline, lightly chitinated, fairly soft, slightly convex. Antenna of eight joints, third or fourth joints longest, formulas: 4, 3 (2, 5) 1, 8, 6, 7 or 3, 4, 8, 2 (1, 5) 6, 7. Rostrum and mentum normal. Legs normal, slender, tibia one-third longer than tarsus; one digitule of claw thicker than the other. Spiracles normal, connected with the margin by a broad band of quinquelocular pores; stigmatic spines in triplicate, the centre one being slightly longer and thicker than the others. Anal cleft open. Plates of anal complex roughly triangular; inner margin longest, with three indentations, in each of which there is a fairly stout seta; base shortest, straight; outer margin convex, apex rounded with three short setae. Multilocular pores present on ventral derm, very numerous, there being a broad band surrounding the anal complex, and seven transverse bands above, the uppermost being between the middle pair of legs. A submarginal band of tubular ducts on ventral surface, those at the cephalic extremity being fewer and more scattered. Ventral derm spines present, very large and conical, with blunt points, those at the posterior extremity in irregular transverse rows. Marginal setae present, simple, also the usual three pairs above anal complex. Very large submarginal tubercules present on dorsal surface, numbering from twenty-eight to thirty, arranged as follows: seven to nine on each side behind posterior stigmatic areas; two between anterior and posterior areas; ten in half circle above anterior stigmatic areas. In old adults the dorsal derm is hard and chitinated, convex, and is evenly punctured with small clear areas or cells. Length of early adults about 2.34 mm.; width about 1.58 mm. Length of old adults 6.80 mm.; width 5.40 mm.

Hab.: On *Wistaria* sp., Ngatea, N.Z.

This is undoubtedly a distinct variety, and it differs from typical *L. persicae* (Fab.) in the following particulars: in having an extra notch and seta on the inner margin of the anal plates, in the much larger submarginal tubercules, in an additional transverse band of

large multilocular pores, in the much larger and differently-shaped ventral spines, and in the dorsal derm-cells being evenly spread over the dorsum. I consider these variations to be sufficient for the erection of a sub-species, but not for a species.

#### ACKNOWLEDGMENTS.

I would like to thank all those who have in any way helped me in the study of this species. To Mr. Harold Morrison my thanks are due for mounted specimens of *L. persicae* (Fab.) collected in the United States, to the Entomological staff of the Cawthron Institute for allowing me the use of their library, and to others for collecting material.

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## A New Species of *Galaxias*.

By G. STOKELI.

[Read before the Canterbury Branch, April 5, 1939; received by the Editor, May 22, 1939; issued separately, March, 1940.]

IN Scott's 1935 revision of the Galaxiidae the genus *Galaxias* is defined as having the dorsal fin inserted well to the rear, the vertebrae numbering more than 50, teeth present on entopterygoids, tongue and jaws, the latter uniserial, and 5, 6, or 7 rays in the ventral fins. The latter character is regarded as of subgeneric importance, the forms having 7 rays being placed in the first subgenus, *Galaxias*, those with 6 having an anagrammatical subgenus *Agalaxis* created for them, while a 5-rayed form is left unaccommodated pending further consideration. The possibility of variation in this character appears to have been disallowed, but the present investigation has shown that variation may occur not only within a species, but within an individual. Of the 10 specimens examined during the preparation of the present paper two have 6 rays in one fin and 7 in the other, one ray in one of the latter fins being rudimentary, five have 7 rays in each fin, one has 7 in one and 8 in the other, one of the latter being rudimentary, and one has 8 in each. A consideration of the specifications of these specimens listed in the appended table reveals no differences in other characters that would suggest specific distinctness of any individual, and it is further to be noted that all had the protruding lower jaw which is so marked a feature of this species. Variation in the number of ventral fin rays has also been observed in several other New Zealand forms, and while it is probable that these are more constant than the present species it is obvious that this character is useless as a sub-generic distinction, and that the divisions proposed by Scott cannot be maintained. The subject of the present paper is therefore referred to *Galaxias*, which is here regarded as a genus without other than specific divisions.

### *Galaxias prognathus* n.sp.

B 6-8, D ii-iv 6-8, A ii-v 7-10, P i-ii 9-12, V 6-8, C v-ix 14 vi-viii. Vertebrae 54-56.

Head 5.80-6.55 in standard length.

Depth 6.47-9.37 in same. Eye 6.0-8.6 in head which is much depressed, its width 1.35-1.78 in its length. Mouth short, maxillary not extending to anterior of eye, lower jaw much the longer. Teeth on tongue biserial, lower jaw without lateral canines, teeth on entopterygoids weak, uniserial in some instances, irregularly biserial or grouped in others; entopterygoid bones fragile. 6-10 gillrakers on lower limb of anterior arch, pyloric caeca lacking in the specimens examined, stomach longer than in *G. attenuatus*. Length of pectoral fin contained 2.3-3.0 in distance from its origin to origin of ventral, ventral inserted at .48-.50 of the standard length, its length contained 2.36-3.04 in distance from its origin to origin of anal. Dorsal inserted at .68-.71 of the standard length, its height contained

.85–1.12 in its basal length. Origin of anal under 4th–5th ray of dorsal, its height contained 1.01–1.16 in its basal length. Caudal moderately emarginate. Least depth of tail contained 2.54–3 in distance from rear of dorsal to base of caudal.

Colour: Greyish mottling on pale slaty ground, ventral surface almost white.

Maximum total length observed 75 mm.

Named on account of the protruding lower jaw.

Holotype in Canterbury Museum.

Type locality, Wilberforce River, Rakaia Valley, Canterbury.

SPECIFICATIONS OF 10 SPECIMENS OF *Galaxias prognathus* n.sp.

Standard length (mm.).	Head in length ratio.	Depth in length ratio.	Length of P. in distance from P. to V.	Length of V. in distance from V. to A.	Dorsal fin insertion ratio.	Ventral fin insertion ratio.	Least depth of tail in distance from D. to C.	B.	D.	A.	V.	Vertebrae.
59	6.55	7.6	3	2.50	.69	.50	2.70	7-8	iii 7	ii 8	8-8	56
55	6.40	8.33	2.65	2.36	.69	.49	2.87	7-7	iv 6	iv 8	6-7*	56
55	6.32	6.87	2.61	2.36	.70	.49	2.71	6-6	iv 6	v 7	7-7	54
52	6.11	8.96	3	2.44	.69	.49	2.75	6-6	iv 7	vi 8	6-7	55
61.5	6.47	6.47	2.91	2.66	.69	.49	2.54	7-7	iv 7	iv 8	7-7	55
47.5	5.93	6.78	2.30	2.46	.68	.49	2.91	8-8	iii 7	iii 10	7-7	55
4 6	6.13	7.66	2.72	2.50	.70	.49	2.62	8-8	iv 7	iv 7	7-8*	56
66	6.31	7.33	2.90	3.04	.71	.48	3	7-7	iii 8	ii 9	7-7	54
37.5	6.20	9.37	2.55	2.40	.69	.50	3.10	7-7	iv 7	iv 8	7-7	56
60	5.80	8.80	3	2.46	.68	.49	2.80	7-7	ii 7	ii 10	7-7	56

\* Includes one rudimentary ray.

### Variation.

The abnormal degree of variation noted in the number of ventral fin rays occurs also in the number of branchiostegals, the same figures applying in each instance. The point of insertion of the ventral fins is more constant than in most species, while the head in length ratio, pectoral ratio and tail ratio is about normal. A variation of 3 in the number of vertebrae is quite usual, but in view of the frequency with which the highest observed number appears in the present group it seems probable that higher counts will be obtained when more material is available. It is also probable that the present limits in other characters will be somewhat extended.

### Affinities.

This species agrees completely with *G. attenuatus* and *G. paucispondylus* in the absence of lateral canines from the jaws and less completely in the elongated body, the point of insertion of the ventral fins and the absence of pyloric caeca; in the two latter species the caeca may be entirely lacking or rudimentary.

*Prognathus* agrees fairly well with *attenuatus* in the length of the pectoral and ventral fins, but differs greatly in the form of the anal. It differs from both of the species mentioned in the shorter

head, the conspicuously protruding lower jaw, and the number of vertebrae; *paucispondylus* has 51-53 vertebrae and *attenuatus*, so far as investigated, 62-63. Species in which the number of vertebrae agrees with, or overlaps, the specification of *prognathus* differ so greatly in other characters that comparison is unnecessary.

*Distribution and Habits.*

*Galaxias prognathus* has been collected from only the Wilberforce and Harper Rivers, in the Rakaia Valley, Canterbury. It has not been taken at altitudes below 2000 ft., but its rarity precludes a precise determination of its range. Spawning appears to occur in late autumn or early winter; males taken in April were almost mature, and a female taken at the same time contained ova measuring 1.16 mm. The smallest mature male observed was 52.8 mm. in total length, and the smallest mature female 67 mm.

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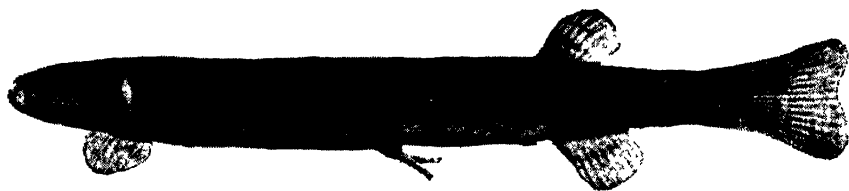


FIG. 1.—*Galaxias prognathus*.



FIG. 2.—Eight-rayed ventral fin of  
*Galaxias prognathus*.  $\times 12$ .



FIG. 3.—Six-rayed ventral  
fin of *Galaxias prognathus*.  
 $\times 12$ .



## A Second Specimen of *Callanthias* in New Zealand Waters.

By DAVID H. GRAHAM, F.R.M.S., F.Z.S.

*Read before Canterbury Branch, August 2, 1939; received by the Editor, August 7, 1939; issued separately, March, 1940.]*

Family SERRANIDÆ.

Genus CALLANTHIAS LOWE.

***Callanthias allporti*** Guenther 1876; Allport's Perch. Plate 58.

A specimen belonging to the genus *Callanthias*, obtained from near Oamaru in 1937 differed both from *C. splendens* Griffin (1921, p. 352, pl. 55; type loc., Hauraki Gulf) and from *C. allporti* Guenther (1876, p. 390; see also Boulenger, 1895, p. 335, pl. 15; type loc., Tasmania). Mr. G. P. Whitley, of the Sydney Museum, commented on a drawing of the Oamaru specimen that it might represent a Forsterian (southern mainland) race of Griffin's species, or that if the lengths of fin-rays and the coloration proved variable it might be included along with the latter in Guenther's species. The latter view was confirmed as follows by the same authority when the specimen was forwarded for examination: "This is a specimen of Allport's Perch from Oamaru, Otago, N.Z., and is the southernmost specimen known. It agrees in all general characters with the Australian *Callanthias allporti*, but has a large eye, inconspicuous lateral line, steep anterior profile and an unusual (perhaps malformed) opercular margin. But Allport's Perch is a variable fish, and it is considered that age and growth would account for the discrepancies between this New Zealand specimen and our Australian and Tasmanian ones. Griffin has described *Callanthias splendens* from the Hauraki Gulf, but it appears as if that, too, is only a variant of *C. allporti*. Some of our *C. allporti* have the eleven dorsal spines and produced fin-rays which Griffin considered were characteristic of his *C. splendens*."

This conclusion is strengthened by the following comparison of the critical numerical data:—

	<i>C. allporti</i> Guenther, type, Brit. Mus.	<i>C. splendens</i> Griffin, type, Auck. Mus.	Otago specimen, Otago Museum.
Dorsal fin-rays ..	xi/X	xi/XI	xi/X
Ventral fin-rays ..	—	i/V	i/V
Anal fin-rays ..	iii/X	iii/XI	iii/X
Pectoral fin-rays ..	—	xxi	xxi
Total length ..	220 mm.	225	412
Length of head ..	55	45	73
Height .. ..	73	65	106
Eye diameter ..	—	15	22

### Description of Otago Specimen.

Length without caudal fin 238 mm.; length of caudal filaments from margin of middle caudal rays 112 mm.; vertical depth from forehead through centre of eye to bottom of jaw 78 mm., representing an extraordinarily steep, convex profile. Dorsal fin placed in a

groove; first dorsal very short. Length of base of dorsal fin 165 mm.; length of anal base 67 mm.; length of snout 20 mm.; depth of caudal peduncle 43 mm.; L. lat. 48–50. First soft dorsal slightly produced, fourth more so and reaching beyond caudal peduncle; operculum armed on its upper posterior margin with two strong, flattened spines, close together, lowest longest. Pores surrounding eye, others scattered about top and sides of head. Preoperculum entire, its angle rounded and smooth. Cleft of mouth oblique. Maxillary extending to as far as the vertical from the eye. Pectorals extend past vent.

*Colour.* Top of head in a line with snout and eye to dorsal, bright yellow; surrounding eye and the opercles silver-white; pectorals yellowish-white; anal fin orange; ventrals yellowish; dorsal spines sulphur-yellow; membranes of dorsals scarlet; from posterior of anal, colour silver, increasing to golden as it reaches ventral fin. Caudal fin yellow, increasing to sulphur-yellow on filaments. Eye yellow, pupil black, three and one-third in head. Ground colour of fish rufous.

*Discussion.* In spite of the large size, the steep and pronounced anterior profile, the larger eye, the unusual opercula, the inconspicuous lateral line, and the extraordinarily long tail filaments (not shown in plate on account of damage in transport), it is provisionally concluded that this specimen is to be included along with *C. splendens* Griffin in *C. allporti* Guenther.

#### *Distribution.*

New South Wales, Victoria, South Australia, and Tasmania (McCulloch, 1909–10, pp. 51, 52; depth 40 fathoms), Hauraki Gulf (Griffin 1921, type of *C. splendens*).

#### *Locality.*

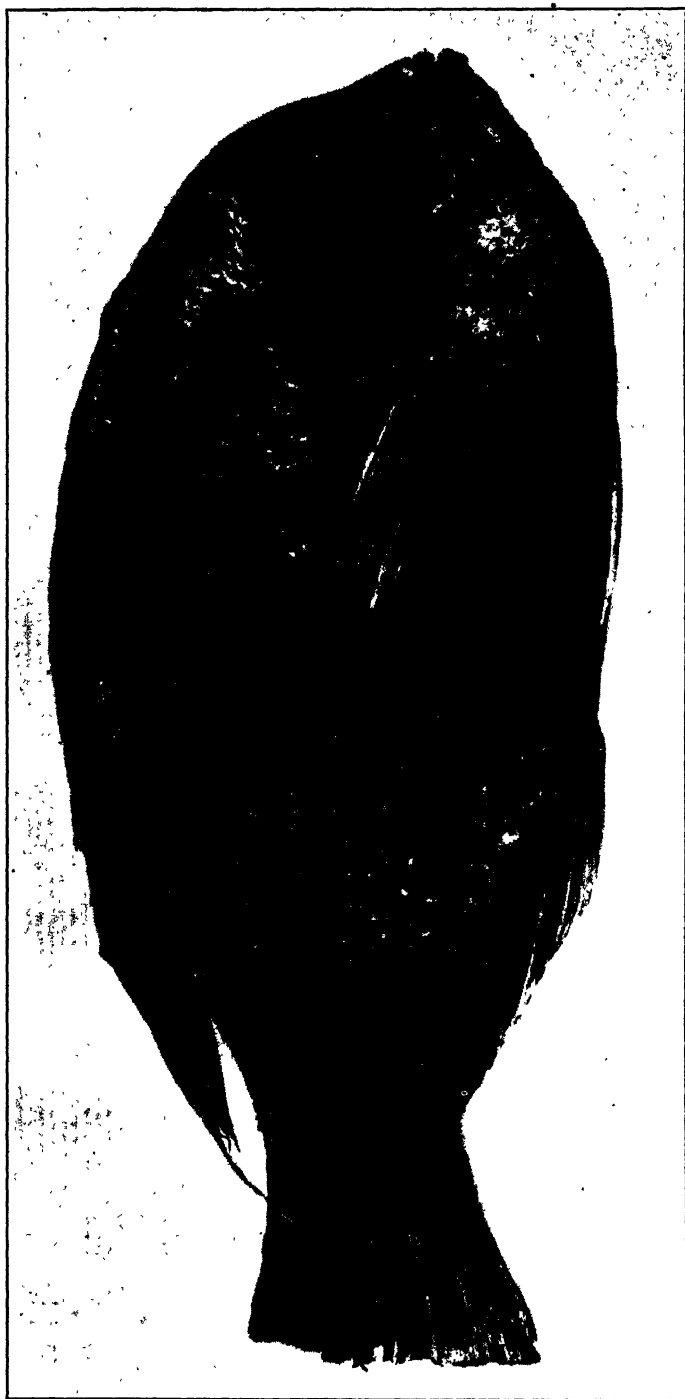
One specimen, 70 fathoms, off Oamaru; taken in July, 1937, on a Dan line by Mr. J. Dow. In Otago Museum.

#### ACKNOWLEDGMENTS.

The writer expresses indebtedness to Mr. Dow for this and other valuable specimens; to Mr. G. P. Whitley for the identification and other information; and to Miss T. Kent, A.R.P.S., for the accompanying illustration.

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*Callanthias allporti* Guenther. Allport's Perch.



## The Waitotaran Faunule at Kaawa Creek—Part 3.

By C. R. LAWs, D.Sc., Auckland.

[Read before the Auckland Institute, April 17, 1939; received by the Editor, May 26, 1939; issued separately, March, 1940.]

### INTRODUCTION.

IN December, 1937, Professor J. A. Bartrum and the writer paid a visit to the beds at Kaawa Creek in the hope that, during the period since their previous one in 1934, further blocks out of the inaccessible fossiliferous bed in the cliff would have fallen on to the beach. There was evidence that several small pieces had been detached, but as these contained little of interest the time was devoted to obtaining matrix that seemed likely to yield minute molluscs.

The list given below shows the records that have now to be added to those given by the writer in his two earlier papers on The Waitotaran Faunule at Kaawa Creek (*Trans. Roy. Soc. N.Z.*, vol. 66, pp. 38–59, 1937; and pp. 99–124, 1937). The 66 additional records in this list (amongst which there are 34 new species, of which 30 are described herein) bring the total for the faunule to 278. In addition to the new records described as new species in this paper, certain previously recorded but unnamed new species are now given names, as better material has been obtained.

Consideration of the list shows much the same association of Miocene and Recent forms, and of shallow and deep-water species, as became apparent from study of the main lists given by the writer (*op. cit.*, pp. 44, 99, 1937), and already commented on in the first of this series of papers. Once again there is evidence of relationship with the Miocene of Gisborne District, *Pallium waikohuensis* Marwick (recorded also from the Waitotaran beds at Hawera by Powell, *Rec. Auck. Inst. Mus.*, vol. 1, no. 2, p. 93, 1931) being a species from the Taranakian of that district, and *Turbonilla praegravata* n.sp. being close to *ngatapa* Marwick, which occurs in the Hutchinsonian of Gisborne. Relationship to Miocene faunas in the South Island is shown by *Salaputium* n.sp., which comes close to the Ototaran *S. animula* (Marwick), *Ataxocerithium pyramidale* Finlay, and *Cylichnina segnis* n.sp., which approaches *C. soror* of the Awamoan. *Zeradina* (*Naridista*) cf. *jocelynae* has affinity with *Couthouyia concinna* Marshall (Awamoan, Target Gully) and *jocelynae* Laws, a species occurring in the beds at Pakaurangi Point (Hutchinsonian).

The following twelve species in the list occur also Recent:—*Zemysia globus*, *Notolepton sanguineum*, *Arthritica bifurca*, *Meliterys parva*, *Rocheortula reniformis*, *Lodderena formosa*, *Liotella polypleura*, *Dolicroseia vesca*, *Scalaronoba costata* (deep water, S.W. Otago), *Haurakia hamiltoni*, *Awanuia dilatata*, *Brookesena succincta*.

*Bartrumella kaawaensis* n.gen. n.sp., previously recorded unnamed, has been found elsewhere in thin shelly streaks in a massive argillaceous sandstone, half a mile north-west of the railway station road, off the main Taupo road, Eskdale (N.Z.G.S. loc. 4332).

The genus *Aupouria* occurs Recent in deep water off Three Kings Islands, and also in mid- and late Pliocene faunas at Nukumaru and Castlecliff. The genus *Alipta* Finlay prior to this has been known by one species in the Recent fauna.

The writer is extremely grateful to Professor J. A. Bartrum for his readiness in assisting with photography; without the benefit of his experience it would have been quite impossible to illustrate this paper; also to Mr. Alma Baker for his hospitality and permission to use his property at Kaawa during collecting.

Unless otherwise stated, the holotypes of species described in this paper are located in the writer's collection.

#### NEW RECORDS OF MOLLUSCS FROM KAAWA CREEK.

- |  |   |
|--|---|
| <i>Aupouria rotunda</i> n.sp.                    | <i>Scalargonoba costata</i> Powell.             |
| <i>Aupouria elongata</i> n.sp.                   | <i>Haurakia hamiltoni</i> (Suter).              |
| <i>Perrierina</i> n.sp.                          | <i>Awanuia dilatata</i> Powell.                 |
| <i>Pallium</i> ( <i>Mesopeplum</i> )             | <i>Linemera kaawaensis</i> n.sp.                |
| <i>waikohuensis</i> Marwick.                     | <i>Linemera</i> sp.                             |
| <i>Cycloclamys</i> aff. <i>transenna</i>         | <i>Notosetia</i> sp.                            |
| (Suter).   | <i>Epigrus waitotarana</i> n.sp.                |
| <i>Salaputium</i> n.sp.                          | <i>Scriptus sinuatus</i> n.sp.                  |
| <i>Cuna ngatutura</i> n.sp.                      | <i>Brookesena succincta</i> (Suter).            |
| <i>Pleuromeris waitotarana</i> n.sp.             | <i>Rissoina ngatutura</i> n.sp.                 |
| <i>Condylocardia dupliora</i> n.sp.              | <i>Rissoina koruahina</i> n.sp.                 |
| <i>Kellya</i> n.sp.                              | <i>Nozeba plana</i> n.sp.                       |
| <i>Zemysia</i> ( <i>Zemysina</i> ) <i>globus</i> | <i>Zebittium tenuicordatum</i> n.sp.            |
| Finlay.  | <i>Socienna</i> cf. <i>maoria</i> Finlay.       |
| <i>Notolepton sanguineum</i> (Hutton).           | <i>Alipta</i> n.sp.                             |
| <i>Arthritica bifurca</i> (Webster).             | <i>Notoseila</i> sp.                            |
| <i>Arthritica dispar</i> n.sp.                   | <i>Atazocerithium pyramidale</i>                |
| <i>Melliteryx</i> n.sp.                          | Finlay.   |
| <i>Melliteryx parva</i> (Desh.).                 | <i>Zeacolpus</i> cf. <i>vittatus</i> (Hutton).  |
| <i>Zemyllita praecursor</i> n.sp.                | <i>Stiracolpus</i> aff. <i>symmetricus</i>      |
| <i>Zemyllita bartrumi</i> n.sp.                  | (Hutton).                                       |
| <i>Rocheffortula reniformis</i> (Suter).         | <i>Proxiuber</i> cf. <i>australis</i> (Hutton). |
| <i>Dosinula</i> ? <i>crebra</i> (Hutton).        | <i>Sinum</i> sp.                                |
| <i>Amphidesma</i> sp.                            | <i>Korovina dupliangulata</i> n.sp.             |
| <i>Scissurella geoffreyi</i> n.sp.               | <i>Turbonilla asperedolata</i> n.sp.            |
| <i>Schismope tertia</i> n.sp.                    | <i>Turbonilla praegravata</i> n.sp.             |
| <i>Lodderena formosa</i> Powell.                 | <i>Chemnitzia</i> cf. <i>mitis</i> Laws.        |
| <i>Liotella polypheura</i> (Hedley).             | <i>Planpyrgiscus disparilis</i> n.sp.           |
| <i>Brookula</i> sp.                              | <i>Finlayola rodata</i> n.sp.                   |
| <i>Brookula</i> ( <i>Aequispirella</i> )         | <i>Eulimella kaawaensis</i> n.sp.               |
| <i>kaawaensis</i> n.sp.                          | <i>Eulimella</i> sp.                            |
| <i>Zalipais probenthicola</i> n.sp.              | <i>Terehimella kaawa</i> n.sp.                  |
| <i>Argalista sola</i> n.sp.                      | <i>Bartrumella kaawaensis</i>                   |
| <i>Dolicrossea vesca</i> Finlay.                 | n.gen. n.sp.                                    |
| <i>Zeradina</i> ( <i>Naridista</i> )             | <i>Balcis</i> sp.                               |
| cf. <i>jocelynae</i> Laws.                       | <i>Philine constricta</i>                       |
| <i>Estea koruahina</i> n.sp.                     | Murdoch and Suter.                              |
| <i>Estea semisulcata</i> (Hutton).               | <i>Cylichnina segnis</i> n.sp.                  |
| <i>Estea ngatutura</i> n.sp.                     | <i>Dentalium</i> n.sp.                          |

## SYSTEMATIC.

**Pronucula ngatutura** (Laws).

This species was founded on a single right valve. Five additional valves have since been collected, one of them a left valve.

**Aupouria rotunda** n.sp. (Fig. 12).

Close to *parvula* Powell, but to be distinguished by smaller size, heavier build, and greater inflation. The prodissocoench is a good deal less in diameter and stands up very much more prominently above dorsal margin. There is a constricted zone below it, and this causes a distinct concavity at the dorsal portion of the posterior end of the valve. Otherwise the shape of the two species is similar. They agree closely in hinge characters. Surface sculptured by concentric corrugations.

Height, 1.0 mm.; length, 1.0 mm.

Type valves and two paratypes were collected.

This form occurs also in the Nukumaruan (Nukumarū).

**Aupouria elongata** n.sp. (Figs. 4, 13).

This species is distinguishable at sight from *rotunda* and *parvula* by its more elongate form, the anterior end being more drawn out. The prodissocoench does not rise above dorsal margin as prominently as that of *rotunda*, but is more like that of *parvula*. Hinge as for *parvula* except that teeth are developed at both extremities of the vertically striated ligamental area. In the right valve there is one strong anterior tooth with a pit on either side of it; the left valve has correspondingly a deep pit which is bordered on opposite sides by teeth to engage in the pits of the right valve. The right valve has two posterior teeth and the left valve one posterior tooth.

Height, 1.0 mm.; length, 1.3 mm.

Type and many paratypes collected.

This species is the form recorded from Kaawa Creek by the writer (*Trans. Roy. Soc. N.Z.*, vol. 66, p. 46, 1937) as “n.gen n.sp. of Limopsidae.”

**Hochstetteria tela** Laws.

Known originally from two right valves. Fourteen additional valves have been obtained.

**Hochstetteria kaawa** Laws.

Originally known from a single right valve. Five further valves have since been collected.

**Hochstetteria pinctagrina** Laws.

Known originally from a pair of odd valves. Two further valves are now to hand.

**Gosa separabilis** n.sp. (Fig. 2).

A near relative of *filholi* (Bernard), but sufficiently distinct in certain characters to warrant a separate name. The hinge characters are closely similar in both species. On the whole, *filholi* is more roundly quadrate in shape than *separabilis*. The latter has markedly fewer ribs (10 as against 14 in *filholi*), and this difference is constant. The concentrics between the radials are on the whole coarser in

*filholi*, and the prodissoconch is wider and not so elevated. The antero-dorsal margin of *filholi* is more nearly horizontal than that of *separabilis*. The lunular area carries two radials in the latter species and four in *filholi*, and is flatter and more sunken in the fossil. Specimens of *filholi* from off Otago Heads have been used in making the above comparisons.

Height, 2.1 mm.; length, 2.0 mm.

This is the form identified by the writer (*Trans. Roy. Soc. N.Z.*, vol. 66, p. 48, 1937) as "*Cosa* cf. *filholi* (Bernard)." Better and more abundant material has made it necessary to recognise the Kaawa shells as distinct.

**Perrierina n.sp.**

This is a very much smaller species than *P. sola*, which also is found in the Kaawa faunule, and differs considerably in shape. It comes nearest to *P. insulana*, a Recent form from the Chatham Islands, although there are considerable differences. It is notably smaller than *insulana*, and has the prodissoconch at about the middle of the dorsal margin. The outline of valve is symmetrical with respect to a line drawn vertically through the prodissoconch, and this separates the species at a glance from all other Neozelanic *Perrierina*. Dentition not well shown owing to wear, but there are two cardinal teeth just in front of prodissoconch of left valve, and only traces of lamellae behind prodissoconch. The right valve shows traces of two small cardinals and a larger one anterior to them. Prodissoconch and bounding rim not rising prominently from surface of valve. Outer surface of valve practically smooth.

Height, 1.0 mm.; length, 1.0 mm.

Odd right and left valves collected. Also three further specimens of *P. sola* have been collected.

**Dacrydium simulator Laws.**

Known previously from a single left valve. Five additional valves have since been collected.

**Pallium (Mesopeplum) waikohuensis Marwick.**

1931. *N.Z. Geological Surv. Pal. Bull.*, no. 13, p. 97.

This record is based on a single well-preserved right valve, which agrees closely with Marwick's figure and description. The type is found in beds of the Ormond Series (Taranakian) of Gisborne District. This constitutes a record new to the locality. It has been recorded from Hawera by Powell (*Rec. Auck. Inst. Mus.*, vol. i, no. 2, p. 87, 1931).

**Cyclochlamys aff. transenna (Suter).**

Several valves, right and left, were collected, but after preliminary examination the tube containing them was mis-laid, and cannot yet be traced.

**Lima cf. colorata Hutton.**

A dozen or so small specimens recently to hand agree almost exactly with juveniles of *colorata* from South Island Awamoan beds.

**Crassostrea ingens** (Zittel).

This species has been recorded by Powell (*Rec. Auck. Inst. Mus.*, vol. 1, no. 2, p. 87, 1931) as occurring at both Waihi Beach, Hawera, and at Waipipi. This is a new record for the Kaawa beds.

**Salaputium** n.sp.

A pair of valves, the left one very badly worn, and neither of them mature, represent this new species. The anterior end is more broadly rounded and not quite so produced as that of *S. animula* (Marwick), and the cardinal tooth, which descends almost vertically in *animula*, is very much more oblique to postero-dorsal margin. Also the concentric sculpture is much coarser, consisting of broad, even nodulations, many fewer in number than those of *animula*. On posterior portion of valve behind the umbonal fold, which is not pronounced, the sculpture weakens almost to obsolescence. This is the first record of the genus in post-Oamaruan deposits. *S. animula* (Marwick) is a fossil from the Ototaran of Chatton, and *S. finlayi* Laws has recently been recorded from the Pakaurangi Point beds (Hutchinsonian). Reference has already been made both by Powell (*Rec. Auck. Inst. Mus.*, vol. 1, no. 2, p. 90, 1931) and by the writer (*Trans. Roy. Soc. N.Z.*, vol. 66, p. 38, 1937) to persistence of certain Oamaruan genera and species into early Pliocene (Waitotaran) deposits in New Zealand.

**Cuna ngatutura** n.sp. (Figs. 7, 25).

This species comes near to both *laqueus* Finlay and *waikukuensis* Powell. Its shape is like that of *laqueus*, but it lacks the distinct radials of that species. Its beak is less prominent than that of *waikukuensis*, and the escutcheon and lunule are better developed. Other features separating it from *waikukuensis* are its more triangular outline; straighter dorsal margins, with the angle between them more acute; more oblique outline, the valve notably drawn down posteriorly (as in *laqueus*). The crenulations of ventral edge, weak ribbing and dentition are closely similar to those of *waikukuensis*.

Height, 1.8 mm.; width, 1.5 mm.

Not uncommon in the sievings obtained in 1937.

**Pleuromeris waitotarana** n.sp. (Figs. 11, 15).

This species is closest to *kapuaensis* Marwick from the Ormond Series (Taranakian) of Gisborne District. *Kapuaensis* has the beak narrow, and not full and rising prominently above dorsal margin of valve as in *waitotarana*; in fact, the whole upper portion of the valve is fuller than that of the Gisborne species. The beak is not so far forward as that of *kapuaensis*, but not central as in *prolutea*. The lunule is more sunken and the anterior dorsal margin more excavated. *Waitotarana* has 17 or 18 radials as against 20 in *kapuaensis*, and has the tubercles elongated transversely and even more densely packed together. The last few (posterior) radials of the Gisborne shell are distinctly weaker than all preceding ones. This is not so in *waitotarana*, where there is a gradual diminishing in strength towards both posterior and anterior ends. *Waitotarana* has the interstices not so narrow relative to width of ribs.

Height, 6.0 mm.; length, 6.0 mm.; inflation, 2.4 mm.

This is the species occurring in previous lists of the Kaawa faunule as *Pleuromeris* aff. *lutea* (Hutton). The much better material recently obtained has made it possible to discriminate more closely.

**Verticipronus stirps** Laws.

Known previously from a single left valve. Eighteen further valves are now to hand.

**Condylocardia dupliora** n.sp. (Fig. 9).

Closely similar to *C. concentrica* Bernard, but to be distinguished by the heavier hinge and dentition; two instead of one heavy rim around the prodissoconch; and fewer, heavier, more widely spaced concentric ridges, rather flattened on top. Basal margin crenate.

Height, 1.1 mm.; length, 1.4 mm.

Localities: Nukumarū (Nukumaruan), 4 specimens (type); Kaawa Creek, a left valve (Waitotaran).

This record adds a further genus to the faunule at Kaawa Creek.

**Zemysia (Zemysina) globus** Finlay.

This record constitutes a new one for the Kaawa faunule. The shells agree almost exactly with topotypes.

**Notolepton sanguineum** (Hutton).

The Kaawa shells identified as this species match very well indeed undoubtedly *sanguineum* from off Otago Heads. They agree with the Recent shells in shape and hinge, but are of somewhat lighter build. This is a new record for the beds.

**Arthritica dispar** n.sp. (Figs. 16, 17).

Shell small, elongate, inequilateral, the beaks situated at posterior third, so that anterior end is considerably longer than the posterior. Anterior end more sharply convex than posterior one. Left valve with a small cardinal tooth with a short lateral on either side. Right valve with a cardinal tooth just anterior to beak, and a small swelling behind it just under umbo; laterals well developed, the anterior one flexed downwards and then straightening out anteriorly. Punctate sculpture finer than that of *elongata*.

Height, 2.1 mm.; length, 3.0 mm.

Type valves and a paratype collected.

**Melliteryx parva** (Desh.).

A single valve agreeing closely with shells from 40 to 50 fathoms off Otago Heads. New record.

**Melliteryx** n.sp. (Fig. 1).

Shell small, elongate, of moderately heavy build. Dentition closely similar to that of *parva* (Desh.). Like *mirificus* Powell and Bartrum it has the beaks central, and in this respect differs from *parva*. *Mirificus*, however, has a different outline, and the height is greater in relation to length; distinguished from *parva* by reason of the centrally placed beaks, which are directed more inwards; the posterior dorsal margin is not as elevated as that of *parva*, and descends much more slowly; basal margin long, faintly convex, not straight like that of *parva*; *parva* has the anterior end more sharply rounded than the posterior, whereas the Kaawa Shell

has the convexity similar at each extremity; the punctate sculpture of *parva* is rather coarser than that of the fossil. *Parva* is higher in relation to length.

Height, 2.2 mm.; length, 2.9 mm.

Two left valves were collected.

**Semeloidea donaciformis** Bartrum and Powell.

This species, along with *S. miocenica* Laws, seems to be congeneric with *Kellya* (*Pythina*) *eocaenica* (de Raine.), from the Eocene of the Paris Basin.

**Zemyllita praecursor** n.sp. (Fig. 10).

There is a single well-preserved right valve. This species is undoubtedly directly ancestral to *stowei*. It has a less convex valve; it is more quadrate in shape, since the posterior dorsal edge descends less rapidly and the basal margin is practically straight, not convex; the beak is distinctly less full and not so prominently rising above dorsal margin; dentition as for *stowei*; ribs more numerous, thinner and sharper than those of *stowei*, 11 in number as against 7 or 8 in the Recent species.

Height, 4.8 mm.; length, 7.2 mm.

This is the "*Zemyllita* n.sp." of the list given by the writer in part 1 of this series of papers (*Trans. Roy. Soc. N.Z.*, vol. 66, p. 54, 1937).

**Zemyllita bartrumi** n.sp. (Figs. 3, 5).

Shell very small, radially ribbed at ends, concentrically ridged over rest of valve. Hinge of right valve not showing cardinals well; anterior and posterior laterals much as in *Z. stowei* (Hutton), the anterior ones relatively longer, however. The sculpture is very distinctive. Towards each end of valve there are six to eight coarse radial ribs, several of which diverge distally. The entire intervening surface is ornamented with close regular concentric ridges which end abruptly against the inner radial at each end, but indicate their presence nearer each end of valve by faint nodulation of radials. The concentric grooves are crossed by radial threads, much finer than the concentric ridges. Margins smooth.

Height, 1.8 mm.; length, 2.5 mm.; inflation (one valve), 0.6 mm.

Type in collection of the Auckland University College. A single right valve, collected by Professor Bartrum.

**Virmysella tellinula** (Odhner).

A larger series of better preserved shells shows that the *Virmysella* from Kaawa Creek cannot be dissociated from *tellinula*. In The Waitotaran Faunule at Kaawa Creek, Part 1 (*Trans. Roy. Soc. N.Z.*, vol. 66, p. 55, 1936) the writer compared certain small specimens with *V. hounsellii* Powell. These, probably referable to *tellinula*, are now in the Auckland Museum, and the writer has not inspected them again.

**Rochefortula reniformis** (Suter).

This is the second *Rochefortula* to be found in the beds at Kaawa. *R. kaawaensis* having been described by Bartrum and Powell in 1928. The record of *reniformis* is based on two small left valves agreeing

entirely with similar valves of Recent specimens. Of the two species *kaawaensis* is very much more common than *reniformis*. This is a new record for the beds.

***Dosinula marwicki* Laws.**

At the time of description only a single left valve was available. A right valve has since been collected, but the hinge is badly damaged.

***Dosinula crebra* (Hutton).**

A small shell measuring about 22 mm. in length was submitted to Dr. Marwick, to whom the writer is indebted for his opinion that it is doubtfully separable from *D. crebra*. The shell has been a little broken at an early stage and has not thereafter grown normally.

***Amphidesma* sp.**

A fragmentary left valve, collected by Mr. C. A. Fleming, has the hinge and form of *Amphidesma*. The shell appears to be unicarinate posteriorly, but the surface is rubbed and secondary carination, if originally present, may have been obliterated. The dentition does not exactly agree with that of any described Neozelanic species.

New record. Specimen in Mr. Fleming's collection.

***Scissurella geoffreyi* n.sp. (Fig. 28).**

*S. apudornata*, a fossil from Target Gully, is larger and has no spirals on the shoulder. *Bountyensis* and *fairchildi*, Recent species from Bounty Islands, lack fenestrated sculpture on the shoulders, which is typical of the new species. *Geoffreyi* is closest to *prendrevillei*, a Recent form from Chatham Islands, but *prendrevillei* has a distinct umbilicus, heavier axials and only 3 as against 6 or 7 spirals on shoulder, as well as other divergent characters. The fine, regular, even sculpture is reminiscent of that on base of *apudornata*. The axial threads are numerous, strongly antecurrent to suture, and of about same strength as spirals. There is slight nodulation at intersection of axials and spirals. Sculpture on base and periphery same as on shoulder. A heavy cord borders umbilicus, which is narrow, though distinctly open. Fasciole not strongly sunken, its bordering ridges scarcely noticeable, crossed by curved axials. Body-whorl evenly convex; spire low, but distinct. Aperture spreading outwards and downwards; basal lip long, descending obliquely to right.

Height, 1.0 mm.; width, 1.0 mm.

Four specimens collected.

***Schismope tertia* n.sp. (Fig. 29).**

Distinctly axially costate on shoulder, thus easily distinguished from *lyallensis*, *laqueus* and *iota*, all of Finlay. Also separable at a glance from *ngatutura* and *koruahina* from the same beds by absence of spiral concavity below fasciole. Further separable from *ngatutura* by presence of distinct, well-developed axials. *Koruahina* has the axials much coarser and heavier. The axials of *tertia* are thin, sharply elevated, distant and antecurrent upwards, both on shoulder and on base. The fasciole is bordered by heavy cords and the interval between them is spanned axially by curved, spaced threads of about same strength as the axials, concave to outer lip. Both shoulder and

base with spiral threads, weaker than axials, through which they pass; three such threads on shoulder of body-whorl. Spiral threads on periphery numerous, spaced, much finer than those on shoulder. Spirals in proximity to umbilicus become stronger, that bordering umbilical depression very coarse; there is a weaker spiral within the depression in some individuals.

Height, 1.0 mm.; width, 1.0 mm.

Five specimens collected.

**Lodderena formosa** Powell.

Seven very nicely preserved shells show all the features of *formosa*, hitherto known only in the Recent fauna from shallow water in northern localities. This is a new record for the Kaawa beds.

**Liotella polypheura** (Hedley).

A single specimen in the collection of Auckland University. A new record for the beds.

**Brookula** sp.

This consists of the body-whorl only, so that specific identification cannot be made. A new record.

**Brookula (Aequispirella) kaawaensis** n.sp. (Fig. 26).

Shell small, height of spire about  $1\frac{1}{2}$  times that of aperture, conic, whorls strongly rounded, sutures distinct. Embryo small, loosely coiled. Aperture circular; umbilicus small but distinct. Body-whorl strongly convex. Sculpture of thin, sharply elevated, distant axial ribs (12 on last whorl), spaced four or five times their own width apart, converging over base into umbilicus.

Height, 1.3 mm.; width, 0.85 mm.

Three specimens collected. This species has the build of *finlayi*, but can be distinguished by its many fewer and heavier axials.

**Zalipais probenthicola** n.sp. (Fig. 8).

Shell very small, similar to *Z. benthicola* Powell. The spire rises only very slightly above the body; much of spire, however, is broken off. Axial sculpture is limited to growth-corrugations, which are crowded and more strongly developed towards end of body-whorl, as in *benthicola*. The basal lip descends from body vertically and is not so concave as that of *benthicola*. The readiest means of separation, however, lies in the presence of spiral sculpture on the fossil. Spiral grooves are very weakly developed on body-whorl above periphery; they are rather better seen on the base; encircling and finally entering the umbilicus there are two spirals threads.

Diameters: greatest, 1.2 mm.; least, 1.0 mm.

The type is unique.

This is the first fossil species of the genus to be described from New Zealand. *Benthicola*, which it closely resembles, is a deep-water species from 170 fathoms off south-west Otago. *Scalargonoba costata* Powell, commented on later in this paper, is also a deep-water species from the same locality.

**Crosseola munditia** Laws.

The type turns out to be a very juvenile shell. There are now three much larger and better specimens. The spiral keels on the

body become in the adult very pronounced and widely spaced, though the axials still remain small and close together. The holotype has 8 spirals on the body; a shell nearer the fully adult stage has 6; whereas fully-grown specimens have only 5.

***Argalista promicans* Laws.**

A further 12 specimens are now to hand, several of which still retain the colour-pattern. The species was originally described as having the surface smooth. It is now possible to state that there are weak spiral grooves on the body-whorl.

***Argalista sola* n.sp. (Fig. 6).**

Shell very small, unsculptured, spire low, aperture circular. Umbilicus narrow but distinct, bounded by a low fold which is faintly microscopically crenulated below. *A. promicans* from the same beds is more depressed and has a widely open umbilicus. *A. micans* Powell also is a smooth form, but differs in features of umbilicus and in the character of its sutures.

Height, 1.0 mm.; width, 1.0 mm.

***Zeradina* (Naridista) cf. *jocelynae* Laws.**

Closely resembles *jocelynae* in form, but has the spire rather taller. It seems to have weaker and not lamellar axials with coarser spirals on the body, but the shells are rubbed. Until better material is forthcoming the Kaawa shells are identified as above.

New record.

***Estea koruahina* n.sp. (Fig. 37).**

Shell small, outline convex, whorls practically flat, sutures very inconspicuous. Sculpture apparently lacking on earlier adult whorls, but distinct axials are present on last few; axials oblique, persisting from posterior suture and ending below at a depression encircling whorl at about its anterior third; a heavy cord margins suture below depression; on the crest of this cord there runs a shallow spiral depression (seen only on well-preserved specimens). The axials are spaced at about their own width apart.

Height, 3.0 mm.; width, 1.5 mm.

Four specimens collected. *Rugosa* Hutton has spiral sculpture more generally developed over whorls; *verticostata* Powell and Bartrum has sculpture present on all adult whorls, and further lacks the heavy cord margining anterior suture.

***Estea ngatutura* n.sp. (Fig. 44).**

Shell very small, unsculptured, with flat whorls, indistinct suture; aperture circular; height of spire about  $1\frac{1}{2}$  times that of aperture. *Insulana* Marwick, a fossil from Chatham Islands, is larger and has more whorls, which are not so flat. The aperture of *insulana* is more laterally situated and not so *Pupa*-like as that of the new species. *Minutula* Powell is smaller and has the whorls convex; also the aperture is not placed so much under the shell. *Gracilispira* Powell is also smaller and has the whorls not flat and the aperture more to the side; also the upper portion of the inner lip is more nearly horizontal in *ngatutura*. *Morioria* Powell, a Recent form from Chatham Islands, is larger, has more whorls, and has the spire higher

relative to height of aperture; further, *moriaria* has light spiral sculpture present. *Rekohuana* is larger and heavier and has different proportions. *Ngatutura* seems to come nearer to *subrufa* Powell than to any other recorded species. *Subrufa*, however, is broader in relation to height, the spire-angle being greater and the body more bulging. The ratio, spire-height: aperture-height, is much the same in both these species.

Height, 1.7 mm.; width, 0.8 mm.

Two specimens. New record.

***Scaloronoba costata* Powell.**

This tiny shell from the Kaawa Creek beds is inseparable from *costata*, agreeing exactly with it in both features of embryo and adult volutions. *Scaloronoba* is represented by a single species, the only other specimens known being two shells from 170 fathoms off south-west Otago. New record.

***Haurakia hamiltoni* (Suter).**

There are three shells that match well specimens of *hamiltoni* from Takapuna. New record.

***Merelina kaawaensis* Laws.**

At the time of description only two or three poorly preserved shells were available. Another 21 shells have since been obtained, several of them in a remarkably good state of preservation. Inspection of these shows certain features that were not clear previously. The protoconch is spirally striated; the axials on the body-whorl end abruptly at a nodule on the second spiral cord from posterior suture; the base is seen to be sculptured by 5 thin, but well-raised spirals, not 3 as stated in the original description.

***Awanuia tenuis* Laws.**

Originally described from one shell. Seven further specimens are now to hand, several of them very much better preserved and larger than the type.

***Awanuia dilatata* Powell.**

This is the first record of the species as a fossil. The writer's description (*Trans. Roy. Soc. N.Z.*, vol. 66, p. 107, 1937) of *Awanuia tenuis* from these beds marked the first record of the genus as a fossil.

***Linemera kaawaensis* n.sp. (Fig. 20).**

Shell small, solidly constructed. Protoconch smooth. Whorls flattish, slightly overhanging suture, which is only moderately distinct. Axials heavy, spaced about own width apart, rounded, vertical, about 12 on last whorl, terminated at periphery. Spirals poorly developed, much weaker than axials, broad, low; three on each of spire-whorls, one bordering each suture and the third around middle of whorl; four on the body-whorl. Base lightly concave. Periphery low down, subangled. Umbilical chink present in some shells.

Height, 1.4 mm.; width, 0.85 mm.

Five shells. The flattish whorls separate it from *maclurgi* Powell, which has somewhat similar heavy axials and few spirals. *Gradata* (Hutton) has flattish whorls, but is much larger, has the sutures strongly cut in, and heavy spirals on periphery and base.

**Linemera** sp.

One small shell, the aperture considerably broken back, and probably not adult. New record.

**Epigrus waitotarana** n.sp. (Fig. 31).

Three specimens have been taken in sievings, one of them complete though not quite adult. This species is more nearly related to the Awamoan *E. fossilis* Finlay than to the Recent *E. striatus*. There is no sculpture other than growth-striae. The aperture is separated from the body by a narrow but distinct groove. The protoconch is smooth, depressed, slightly overhanging next whorl, flattened on top. The flattened top shows about  $1\frac{1}{2}$  minute coils. Outer lip strongly variced externally.

Height, 1.5 mm.; width, 0.6 mm.

Differs from *fossilis* in having the aperture more oblique to axis of shell, the basal lip being more broadly rounded. The sutures are strongly impressed, not channelled as are those of *fossilis*, and the body does not narrow behind to the same extent that it does in the Awamoan fossil. The peculiar protoconch does not seem to be that of *Epigrus*. *Fossilis*, with which this shell is undoubtedly congeneric, is known only from an incomplete specimen lacking the apex. *Waitotarana* bears a striking resemblance to *Chevallieria cylindroides* Cossm. from the Paris Eocene.

**Dardanula** n.sp.

Shell small, outlines straight, apex broad over summit, whorls quite flat, suture very indistinct, indicated merely by a faint linear groove. Whorls sharply angled at periphery; body-whorl not sharply, but distinctly, angulated. Base flatly convex. A faint narrow umbilical depression present. Outer lip broken back. Nearest to *D. rivertonensis* Finlay, from which it can be distinguished by its perfectly flat whorls, less distinct suture, and blunter, heavier spire. Nor is it unlike *D. praecursor* Laws, a fossil recently described from Pakaurangi Point. *Praecursor*, though angulated around periphery, is smaller, has whorls lightly convex, and is not of such heavy build. In the Kaawa shells the spire-angle is wider than that of *rivertonensis* and *praecursor*.

This is the "*Dardanula* n.sp." of the former Kaawa list (*Trans. Roy. Soc. N.Z.*, vol. 66, p. 106, 1937), and although a large number of additional specimens has been obtained, yet a shell that would make a good type has not so far been collected.

**Scrupus sinuatus** n.sp. (Fig. 24).

Shell very small, height of spire a little greater than that of aperture, whorls very convex, strongly shouldered; sutures very distinct. This species shows well all the features of aperture and of protoconch typical of the genus. The sutural sinus is very pronounced, but the notch on basal lip is much less marked than that of *S. hyalinus*, the genotype. In umbilical characters *sinuatus* closely resembles *hyalinus*. There is a crowding together of growth-lines towards outer lip (which is sinuous), causing the formation of a light varix. The subplication on columella, found in *hyalinus*, seems not to be present in the new species. On the body-whorl there are visible here and there low, weak spiral threads.

Height, 1.3 mm.; width, 0.8 mm.

Two specimens. Nearer to *hyalinus* (Odhner) than to *uniliratus* Powell. Differs from *hyalinus* in being a good deal smaller, not so expanded across body, and in having sutural sinus narrower and deeper. This is the first fossil species of the genus to be described.

**Brookesena succincta** (Suter).

Two shells, one of them well preserved. Spirals on the base, however, if present, are obscure. This is a new record. A Miocene species of *Brookesena* has recently been described by the writer from the Pakaurangi Point beds.

**Rissoina ngatutura** n.sp. (Fig. 27).

Of the Neozelanic species of *Rissoina* so far described only the following four species bear sufficient resemblance to make comparisons necessary—*anguina* Finlay, *chathamensis* (Hutton), *powelli* Finlay, *rufolactea* (Suter). *Ngatutura* differs from *anguina* in having the spire higher relative to height of aperture, and in possessing fewer axials per whorl (14 to 15 against 24 in *anguina*); *chathamensis* is larger, of heavier build and not so slender in proportions, the spire being less tapering; the Kaawa species somewhat resembles *powelli* in outline, but is very much smaller, with relatively heavier, more widely spaced and fewer axials; *rufolactea* is smaller and has not the spiral striae of *ngatutura*; also the aperture is higher in proportion to height of shell than that of *ngatutura*; the axials number about the same in both these species.

Height, 5.1 mm.; width, 2.1 mm.

Two specimens. New record.

**Rissoina koruahina** n.sp. (Fig. 32).

Shell very small, in fact the smallest Neozelanic species of the genus. Surface worn, but faint axials are present on upper whorls of spire. Whorls lightly convex, suture moderately distinct, below periphery, margined by a slight thickening around posterior of whorl. Summit of shell flattened and spread laterally, the apical whorl being low and flattish on top. Peristome thickened; outer lip straight above, when viewed laterally, and broadly convex anteriorly; basal lip heavy and broadly rounded; parietal wall lightly callused.

Height, 2.0 mm.; width, 0.9 mm.

**Nozeba plana** n.sp. (Fig. 35).

This species lacks spiral ornamentation over the whorls, and in this respect, as well as in form, differs from *emarginata*. *N. coulthardi* is described as having no spirals on whorls, but some of Webster's paratypes show distinct spiral grooves when inspected microscopically. The spirals of *emarginata* are visible under the hand-lens. *Mica* Finlay is a smaller species than *plana*, and has faint microscopic spirals on periphery. *Plana* is entirely unsculptured except for 5 or 6 grooves at anterior end of base; it is less tapering than either *emarginata* or *coulthardi*, has the aperture higher relative to height of shell, and the body-whorl broadly rounded in one even sweep from suture to base (no suggestion of angulation as in the other two species). The parietal wall is not heavily padded with callus, and there is no umbilical chink present.

Height, 2.3 mm.; width, 1.4 mm.

Two specimens. The holotype is a beautifully preserved shell, perfect in every respect.

**Zebittium tenuicordatum** n.sp. (Fig. 42).

Shell small, tapering, outlines lightly convex. Protoconch of  $1\frac{1}{2}$  volutions, smooth, convex. Whorls  $8\frac{1}{2}$ , flat to very faintly convex; sutures not distinct. First post-nuclear whorl with three well-marked spirals, becoming progressively stronger towards anterior. On third whorl a fourth weak spiral thread appears between the two anterior ones. Fourth whorl with four well-marked spirals, the anterior three of equal strength, the posterior one weaker. On the sixth whorl a weak spiral thread appears between the two posterior cords, and develops on the next whorl into a primary cord, a new spiral thread now appearing between the second and third from the anterior suture. On the body-whorl there are 8 primary cords, becoming progressively stronger in order from the suture. These are followed by two weak spiral threads on base, and then a pair of heavy cords, after which there is another indistinct one. Periphery low down, bulging. Base excavated. Inner lip thickly callused from suture to anterior end of pillar. Outer and basal lips broken away. Not far back from outer lip there is a broad, low swelling suggesting a varix, and another, much weaker, near the posterior angle of aperture. There are fine axial growth-striae seen in the spiral grooves, and faint indication of axials can be seen on later whorls in favourable light.

Height, 6.5 mm.; width (estimated), 2.0 mm.

There is the type and many fragmentary and juvenile paratypes. *Z. laevicordatum* also lacks axials, but has the spirals much less developed. *Z. exile* has the spirals nodulated and *vitreum* is reticulated.

**Socienna** cf. **maoria** Finlay.

Apical whorls plus protoconch of two shells very close indeed to *S. maoria* in both embryonic and shell features. New record.

**Alipta** n.sp.

There is one specimen with the protoconch and  $3\frac{1}{2}$  post-nuclear whorls remaining. It has the same peculiar embryo as *A. crenistria* (Suter), but differs in the sculpture of the adult whorls. Though the specimen is obviously distinct from *crenistria* the provision of a name is left in the meantime in the hope that a fully mature shell may be obtained. New record.

**Zaclys spiculum** n.sp. (Fig. 21).

This is the "*Zaclys* n.sp." recorded by the writer from the Kaawa beds in a previous paper (*Trans. Roy. Soc. N.Z.*, vol. 66, p. 107, 1936). A good adult specimen and many immature ones have since been collected. The outline is convex and the protoconch typical. The suture is not margined as in *Z. sarissa*, nor is it so oblique; *sarissa* has the axials somewhat oblique; the spirals of *sarissa* are evenly spaced and the two lowest ones have their gemmules stronger than those on the upper one. In *spiculum* the upper two spirals are close together, and all three spirals are of equal strength. There is no spiral ridge

on base running up to columella, as in *sarissa*. *Z. paradoxa* is a more stumpy type of shell with only two rows of gemmules. *Z. subantarctica* is larger, has a taller and relatively narrower embryo and straighter outline.

Height, 3.0 mm.; width, 1.0 mm.

There is the type along with many small paratypes.

**Notoseila sp.**

Three apical fragments, protoconch intact. New record.

**Ataxocerithium pyramidale** Finlay.

There are two fragmentary specimens having the build, sculpture and suture entirely in accord with that of *pyramidale*. New record.

**Notosinister kaawaensis** n.sp. (Fig. 30).

Very much better material now to hand has shown that this form, identified as *N. infelix* (Webster) in the writer's previous paper (*Trans. Roy. Soc. N.Z.*, vol. 66, p. 108, 1936), is distinct from that species. Actually it is nearer to *N. aupouria* Powell, a shell from 260 m. off Three Kings Islands, which was described subsequently to the 1936 record of *infelix*. The protoconch is broader in relation to height than is that of *aupouria*. The second embryonic volution has two faint spiral threads anteriorly; on the third these become cords of equal strength set on the periphery; on the last embryonic whorl the posterior cord becomes weaker, the anterior one becoming a pronounced keel at about anterior third. Upper whorls of spire have two equal gemmate spirals; on the last few whorls a third intermediate one appears first as a fine thread, which ultimately on body-whorl attains the strength of those above and below it. The gemmules are round in shape and not elongate from side to side as are those of *aupouria*. Like *aupouria* it has the canal almost closed and tubular; the outer lip, however, does not spread laterally, but continues the outline of the spire downwards.

Height, 3.9 mm.; width, 1.2 mm.

Type and many paratypes.

**Lilax spp.**

About 30 protoconchs of *Lilax* have been collected. They show a good deal of variation in embryonic ornamentation. Four individuals have the same granulate sculpture as *L. nucleogranosum*, but their coiling is looser and they are larger; three others have the sculpture of heavy, rounded granules, many fewer than those of *nucleogranosum* and not closely packed together; the remainder are all consistently alike and intermediate between the former two types. It is possible that a bigger range of specimens would show intergrading, but the extremes are a long way apart. The last type referred to above is the "*Lilax* n.sp." listed by the writer in a previous paper (*Trans. Roy. Soc. N.Z.*, vol. 66, p. 108, 1936).

**Zeacolpus cf. vittatus** (Hutton).

There is a single specimen with the apical whorls decollated. The four keels are present, the lower two of equal strength, but more prominent than the upper two, of which the posterior is the weaker.

There is a wide intervening zone between the two pairs of keels, and this has a very faint interstitial riblet. It is very close indeed to an undescribed form occurring in the Awamoan beds at Pukeuri. New record.

***Stiracolpus* aff. *symmetricus* (Hutton).**

There are the apical whorls of two shells, distinct from apices of *S. kaawaensis*, that resemble closely those of Recent and Castlecliffian *symmetricus*. They are, however, rather more slender in outline, and have the cords not so heavy. New record.

***Pareora striolata* (Hutton).**

This record was based on a single shell. Another specimen has been obtained. The genus is thus rare in the Kaawa faunule, though abundant at many Awamoan horizons. These Waitotaran individuals are no doubt stragglers from the Miocene, the genus here being well on its way to extinction, for it seems not to occur in post-Waitotaran deposits.

***Cheilea postera* Laws.**

A third specimen has been found, and of better preservation than the type. The embryo is preserved and is seen to be laterally coiled in a loose helicoid spiral.

***Sinum* sp.**

There is a small individual that has the appearance of an immature *marwicki* Laws. It may possibly be the same as that recorded as *Sinum* cf. *marwicki* by Powell from the Waitotaran beds at Hawera (*Rec. Auckland Inst. Mus.*, vol. 1, p. 98, 1931). New record.

***Korovina dupliangulata* n.sp. (Figs. 14, 36, 38).**

Shell small, flat, body very wide-spreading, spire insignificant but rising sharply, ornamented by numerous close, curved axials, hairlike under hand-lens. Aperture very wide; columella long, straight; junction of basal and outer lips angulated; umbilicus wide, conspicuous, bordered by an angulated fold; growth-lines coarse and heavy entering umbilicus. Suture of last whorl deeply sunken. The body is strongly angulated by a pronounced ridge which emerges just below suture and sweeps around concentric with the umbilical fold to end at the junction of basal and outer lips. The umbilical fold ends at base of columella, which becomes expanded at this point. Outer lip somewhat sinuated behind by a broad, shallow depression which develops not far below suture towards close of last whorl. Protoconch unsculptured.

Height, 1.1 mm.; width, 1.95 mm.

Six specimens.

***Turbonilla koruahina* Laws.**

The type was the only specimen available at the time of description. Two further specimens agreeing exactly with it are now to hand.

***Turbonilla asperedolata* n.sp. (Fig. 23).**

Shell small, elongate-conic, of  $5\frac{1}{2}$  post-nuclear whorls. Whorls flat, lightly constricted at upper third; sutures indistinct on periphery; outlines of spire straight. Protoconch heterostrophe, convex over

summit, planorbid, considerably tilted, nucleus considerably immersed. Axial ribs (12 on penultimate whorl) broad, heavy, roughly hewn, slightly oblique (retrocurrent above), dying out at periphery (above suture on spire-whorls); intercostal spaces somewhat narrower than ribs, fairly deeply excavated. Body-whorl flat above, strongly convex over periphery, lightly convex on base. Aperture pyriform, angled behind, moderately wide in front. Columella short, thickish, slightly arcuate, set vertically; a small, fairly distinct fold just below insertion of columella. Parieto-columellar junction obtusely angulated.

Height, 2.4 mm.; width, 0.8 mm.

Eight specimens collected. The quite flat whorls and rude, oblique axials distinguish this species from its associates in *Turbonilla* Group B (i.e. *Turbonillas* with planorboid embryo. See *Trans. Roy. Soc. N.Z.*, vol. 66, p. 418, 1937).

***Turbonilla praegravata* n.sp. (Fig. 34).**

There is one moderate-sized shell somewhat similar to *T. ngatapa* Marwick, a fossil from Gisborne District. The whorls are flat but with a sulcus around the summit of upper ones, the sulcus shifting further forward and becoming about median on later ones. The plait is not strongly developed. Whorls staged or telescoped. The most outstanding feature of the species is the tremendous protoconch with closely coiled, projecting lateral nucleus, the embryo being out of all proportion to the size of the early post-nuclear whorls. Axials are represented as close, weak, oblique folds, hardly visible (the specimen is rubbed) and apparently restricted to the posterior and anterior thirds of whorls (not developed in sulcus).

This new species is obviously close to the rather peculiar Gisborne *Turbonillas*. The Gisborne Pyramidellidae on the whole have a facies all their own; the present shell and *Waikura* from the Kaawa beds show distinct alliance with certain of Marwick's species from Gisborne. New record.

Height, 3.0 mm.; width, 1.0 mm.

***Chemnitzia quadruplator* n.sp. (Fig. 39).**

Shell small, elongate-conic, of  $5\frac{1}{2}$  to 6 post-nuclear whorls; outlines of spire straight. Whorls flatly convex; suture not strongly marked, very little cut in. Protoconch decollated in all specimens. Axials (about 13 on penultimate whorl) coarse, rounded, a little oblique, straight; interspaces of rather less width than ribs, well excavated, stopped abruptly at periphery. Body-whorl flatly convex above, its periphery sub-angled, base lightly convex. Aperture sub-quadrate; columella heavy, short, faintly arcuate, set vertically; basal lip moderately broadly rounded; outer lip straight; parieto-columellar junction obtusely angled.

Height, 2.9 mm.; width, 0.8 mm.

Seventeen specimens collected. *C. waitemata* Laws has convex whorls with sutures more cut in, and finer axials; *C. jactura* has the sculpture somewhat similar to that of *quadruplator*, but has convex whorls and more distinct suture; *C. barrierensis* has wider intercostal spaces and more convex whorls.

**Chemnitzia ngatutura** n.sp. (Figs. 19, 43).

Shell of moderate size, elongate-conic; whorls flat, much broader than high, cut in close to suture. Axials (about 18 to 20 on penultimate whorl) not high, broad, flattish, vertical, straight; interspaces very narrow and not deep. Protoconch distinctive, large, heavy, bulbous, coiled in a high helicoid spiral, the lateral nucleus considerably overhanging first post-embryonic whorl. Body-whorl flattish above, strongly convex at periphery, lightly convex on base. Aperture subquadrate, basal lip widely rounded. Columella arcuate, set verically, a light fold high up.

Height (estimated), 4.0 mm.; width, 1.3 mm. Larger individuals occur.

This species comes between *C. dunedinensis* and *C. errabunda*. The heavy, high helicoid embryo distinguishes it.

**Chemnitzia** cf. *mitis* Laws.

There is one small shell of rather needle-like habit that approaches *C. mitis* very closely. The whorls, however, are not quite so convex. New record.

**Chemnitzia** sp.

There are about ten fragmentary shells, none of them with the protoconch intact.

**Planpyrgiscus disparilis** n.sp. (Fig. 22).

Shell small, of about 4 whorls, height of spire three times that of aperture or a little over, outlines straight. Protoconch depressed, no lateral nucleus visible, broad over summit. First post-nuclear whorl much wider than embryo, giving a blunt effect to the top of the shell. Whorls evenly convex, widest at middle, narrowly shouldered above; suture channelled. Axial ribs (about 18 on penultimate whorl) moderately strong, broad; width of interstices a little less than that of ribs. Spiral sculpture of numerous raised threads in interstices of all adult whorls; not seen on base, which is rubbed. Height of body-whorl one-half that of shell; body convex above, greatest bulge over periphery, lightly convex on base. Aperture rather broadly ovate, wider in front. Posterior of outer lip turned in at right angles to suture. Columella strongly arcuate, set vertically, short; parietal wall lightly callused; a low fold present well within aperture; small umbilical chink present.

Height, 2.0 mm.; width, 0.8 mm.

One specimen. Though referred to *Planpyrgiscus* it has not the attenuate habit of Turbonillids. One rather hesitates to associate it with *extenuata*, the genotype, but there is no option at present, for it conforms with *Planpyrgiscus* in coiling of embryo, sculpture, and practical absence of plait.

**Finlayola rodata** n.sp. (Fig. 40).

The apex is missing, but on account of similarity of habit with such forms as *F. finlayi* and *F. lurida*, this shell is placed in *Finlayola* rather than in *Syrnola*. It is at once separable on account of the long body-whorl, whose length is over one-third that of the shell. The columella-fold is unusually pronounced, thus distinguishing it further

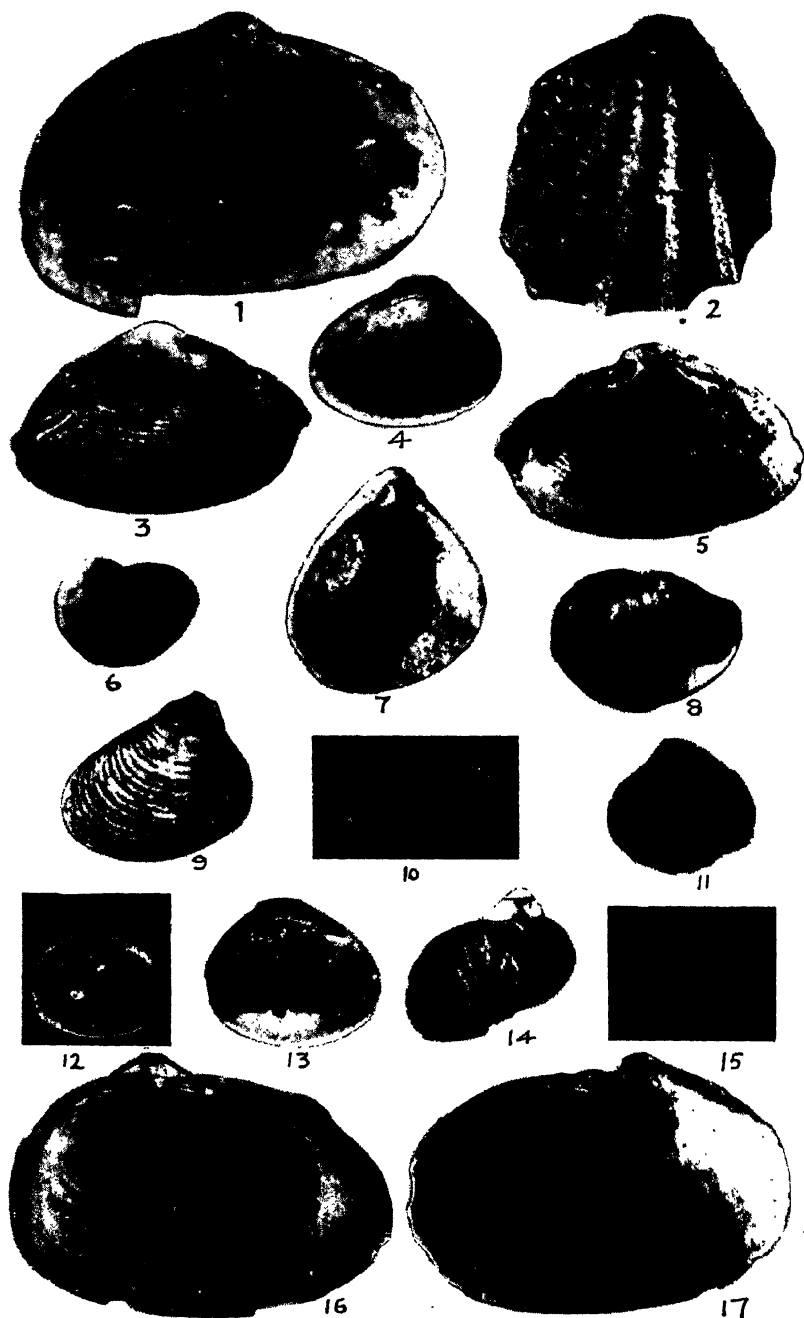


FIG. 1.—*Meliteryx* n.sp.;  $\times 11$ . FIG. 2.—*Coxa separabilis* n.sp.; holotype,  $\times 10$ . FIGS. 3, 5.—*Zemyllita bartrumi* n.sp.; holotype;  $\times 18$ . FIGS. 4, 13.—*Aupouria elongata* n.sp.; holotype,  $\times 20$ . FIG. 6.—*Argalita sola* n.sp.; holotype,  $\times 20$ . FIG. 7.—*Oona ngatutura* n.sp.; holotype,  $\times 19$ . FIG. 8.—*Zaphais probenthicola* n.sp.; holotype,  $\times 20$ . FIG. 9.—*Condylocardia duplora* n.sp.; holotype,  $\times 10$ . FIG. 10.—*Zemyllita praecursor* n.sp.; holotype,  $\times 3.3$ . FIGS. 11, 15.—*Pleuromeris waitatara* n.sp.; holotype,  $\times 3.5$ . FIG. 12.—*Aupouria rotunda* n.sp.; holotype,  $\times 20$ . FIG. 14.—*Korovina dupliangulata* n.sp.; paratype,  $\times 12.6$ . FIGS. 16, 17.—*Arthritica dispar* n.sp.; holotype,  $\times 18$ .



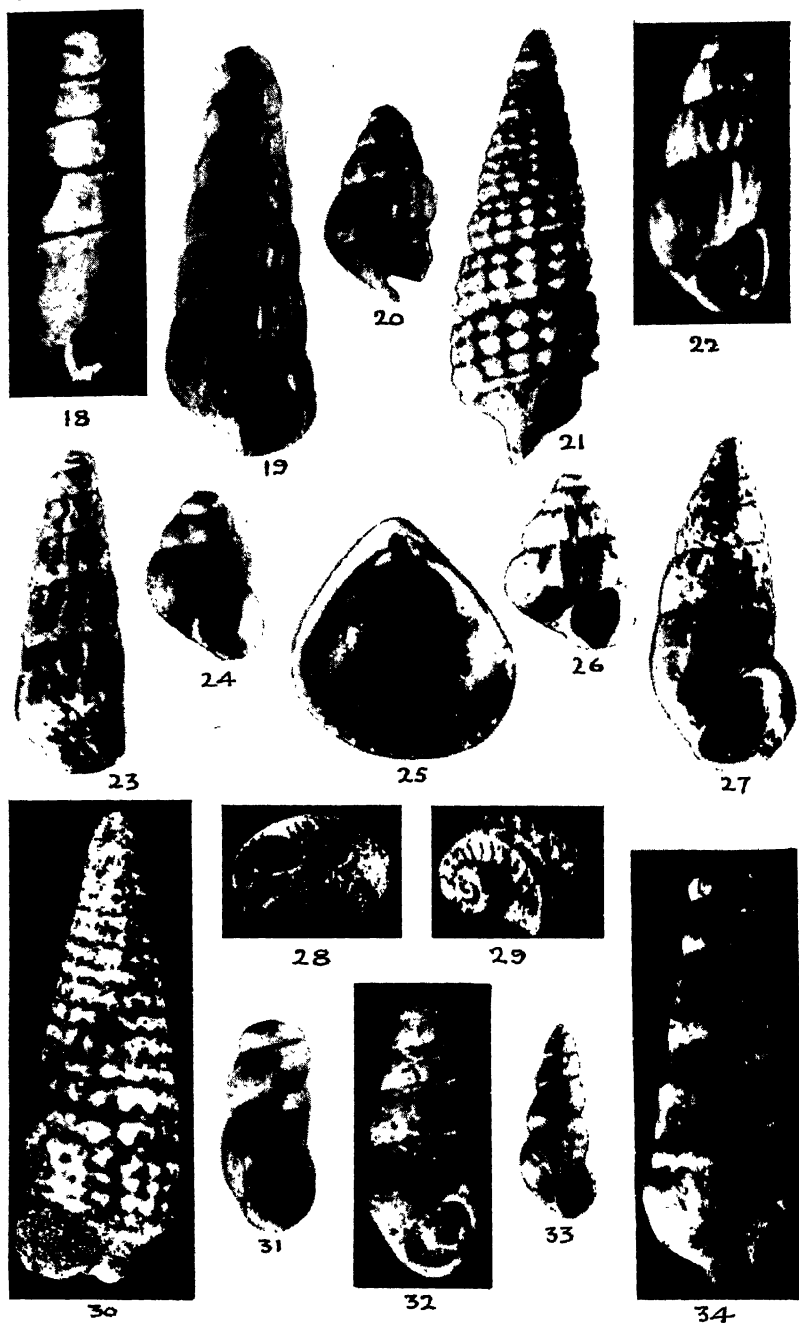


FIG. 18.—*Eulimella kaawaensis* n.sp.; holotype,  $\times 21$ . FIG. 19.—*Chemnitzia ngatutura* n.sp.; holotype,  $\times 18$ . FIG. 20.—*Linemera kaawaensis* n.sp.; holotype,  $\times 20$ . FIG. 21.—*Zactys spicatum* n.sp.; holotype,  $\times 22$ . FIG. 22.—*Planapurgiscus disparilis* n.sp.; holotype,  $\times 21$ . FIG. 23.—*Turbonilla aspredolata* n.sp.; holotype,  $\times 20$ . FIG. 24.—*Scrupus sinuatus* n.sp.; holotype,  $\times 20$ . FIG. 25.—*Cuna ngatutura* n.sp.; holotype,  $\times 19$ . FIG. 26.—*Brookula (Aequispirella) kaawaensis* n.sp.; holotype,  $\times 20$ . FIG. 27.—*Rissolina ngatutura* n.sp.; holotype,  $\times 9.8$ . FIG. 28.—*Scissurella geoffreyi* n.sp.; holotype,  $\times 20$ . FIG. 29.—*Schisnope tertia* n.sp.; holotype,  $\times 19$ . FIG. 30.—*Notosinister kaawaensis* n.sp.; holotype,  $\times 22$ . FIG. 31.—*Eptigrus ngatutura* n.sp.; holotype,  $\times 22$ . FIG. 32.—*Rissolina karuahine* n.sp.; holotype,  $\times 20$ . FIG. 33.—*Eptigrus ngatutura* n.sp.; holotype,  $\times 22$ . FIG. 34.—*Rissolina karuahine* n.sp.; holotype,  $\times 20$ .



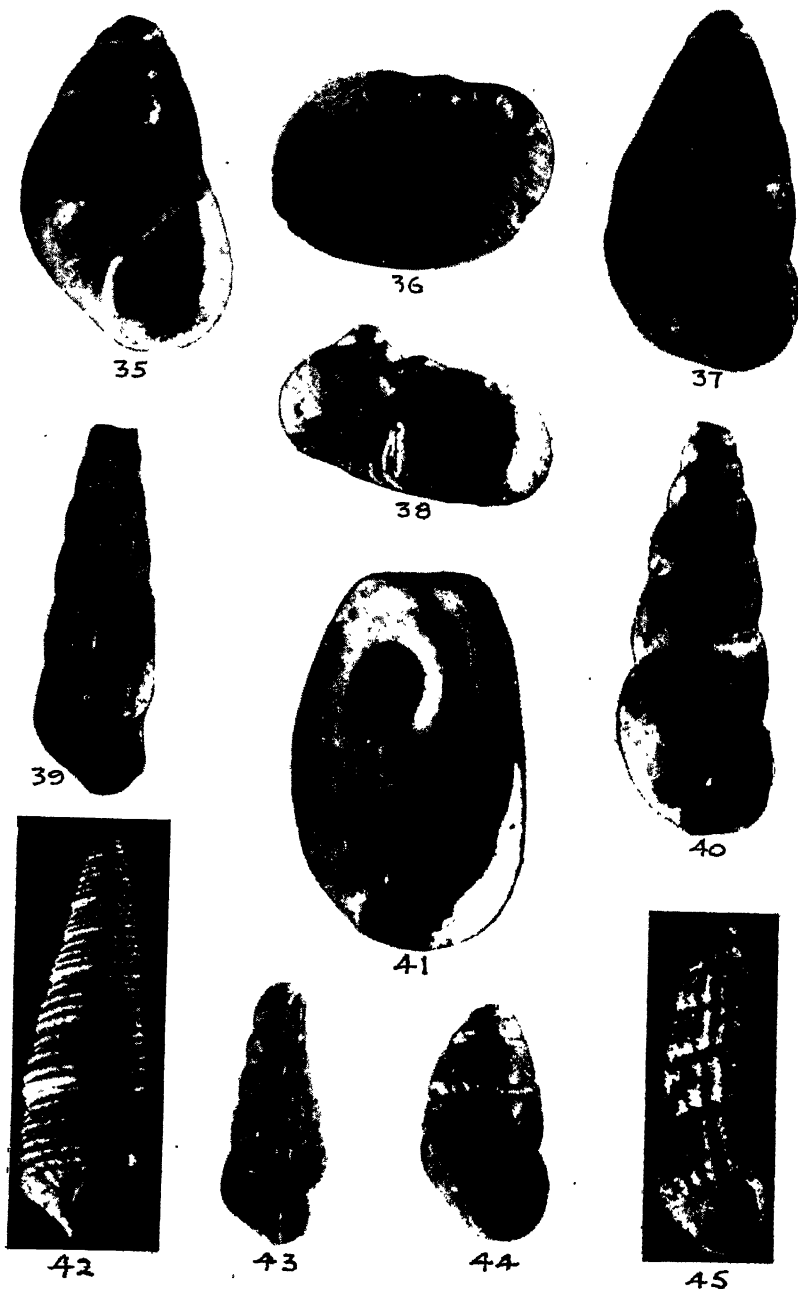


FIG. 35.—*Nozoba plana* n.sp.; holotype,  $\times 22$ . FIGS. 36, 38.—*Korovinella dupliangulata* n.sp.; holotype,  $\times 20$ . FIG. 37.—*Estea kornahina* n.sp.; holotype,  $\times 18$ . FIG. 39.—*Chemnitzia quadruplata* n.sp.; holotype,  $\times 19$ . FIG. 40.—*Pinlayella rotata* n.sp.; holotype,  $\times 20$ . FIG. 41.—*Cylichna segnis* n.sp.; holotype,  $\times 20$ . FIG. 42.—*Zebittium tenuicordatum* n.sp.; holotype,  $\times 0.5$ . FIG. 43.—*Chemnitzia ngatutura* n.sp.; paratype. FIG. 44.—*Estea ngatutura* n.sp.; holotype,  $\times 20$ . FIG. 45.—*Bartrumella kaiaiaensis* n.gen. n.sp.; holotype,  $\times 22$ .



from *finlayi* and *lurida*. The strongly excavated pillar is also reminiscent of these two forms, but the columella is more excavated still in *rodاتا*.

Height, 3.0 mm.; width, 1.0 mm.

The type is the only specimen.

***Eulimella kaawaensis* n.sp. (Fig. 18).**

Shell very small, elongate-conic, outlines straight. Post-nuclear whorls high in relation to width, flat; sutures moderately distinct. Protoconch heterostrophe, exsert, its nucleus coiled in a distinct helicoid spiral, the lower edge of nucleus clear of suture of first post-embryonic volution. Whorls unsculptured. Body-whorl flat above, rounded evenly over periphery, base lightly convex; aperture sub-quadrate; columella set vertically, faintly arcuate. There is no plait.

Height, 2.5 mm.; width, 0.8 mm.

Seven specimens. *E. coxi* has the protoconch blunter, less exsert, with its nucleus less elevated; and the adult whorls broader relative to height. *Deplexa* and *media* are stouter and have the whorls convex.

***Eulimella* sp.**

There is one specimen of a fairly stout *Eulimella*, the protoconch missing, that it is not easy to match with any described form, nor yet can one be sure of its distinctness. Further material is necessary. New record.

***Terelimella kaawa* n.sp. (Fig. 33).**

Closely related to *T. larochei*, but to be distinguished by its heavier and broader embryo, less attenuate apical whorls and different suture. *Larochei* has the suture impressed; that of the present species is tangential, each whorl more or less clasping its predecessor. The columella is arcuate and not straight as in *larochei*. The whorls are not evenly convex; but more bulging below.

Height, 1.4 mm.; width, 0.5 mm.

Localities: Kaawa Creek (type); shelly streaks in massive argillaceous sandstone, half mile north-west of railway station road, off main Taupo road, Eskdale (N.Z.G.S. loc. 4332).

Several specimens.

**Genus BARTRUMELLA n.gen.**

Type: *Bartrumella kaawaensis* n.sp.

This is a Pyrgulinid genus of elevated habit, with strong pillar-plait, axial costae, and spiral sculpture (much finer than the axials) developed as fine, raised, intercostal threads. Spirals are present throughout the whole length of the intercostal spaces on all whorls and on base. The posterior spiral (on shoulder) is coarse and nodulates the summits of the axials. The axial ribs evanesce gradually on the base. The protoconch is planorboid. The spirals are not sufficiently strong to cause reticulation of sculpture (as in *Trabecula Monterosato*), and are just visible under the hand-lens in the type-species.

The writer has very much pleasure in naming this genus in honour of Professor and Mrs. J. A. Bartrum, of Takapuna, Auckland.

**Bartrumella kaawaensis** n.sp. (Fig. 45).

Shell very small, high conic, *Turbonilla*-like in form and gross sculpture, height of spire about  $3\frac{1}{2}$  times that of aperture, outlines slightly convex. Post-nuclear whorls convex, almost tabulated above, strongly contracted to suture below; suture very distinct and well cut in. Embryo planorboid, paucispiral. Axial ribs (about 15 on penultimate whorl) strong, rounded, vertical, straight, extending across entire whorl, evanescent gradually low down on base; spiral sculpture of raised threads in interstices and on base, about 8 of these on penultimate whorl. Body-whorl strongly shouldered above, lightly convex over centre; periphery low, convex; base short; aperture broadly sub-ovate, angled behind, rounded in front; columella short, set vertically, its plait distinct, situated at insertion; basal lip moderately widely rounded; outer lip broken.

Height, 2.3 mm.; width, 0.6 mm.

Localities: Kaawa Creek (type); shelly streaks in massive argillaceous sandstone, half mile north-west of railway station road, off main Taupo road, Eskdale (N.Z.G.S. loc. 4332).

About 30 specimens collected. At first sight *kaawaensis* suggests *Turbonilla*, but the character of the spiral sculpture and the presence of a plait indicates a Pyrgulinid group.

This is one of the forms included under "N.gen. aff. *Pyrgulina*" in the writer's list of Kaawa Creek Pyramidellids (*Trans. Roy. Soc. N.Z.*, vol. 66, p. 112, 1937). Very much better material has since been obtained.

**Neothais (Dicathais) cf. scalaris** (Menke).

This is the form recorded previously from two very fragmentary specimens as *Lepsia* cf. *haustum* (Martyn). Mr. C. A. Fleming has obtained a very much more complete shell, undoubtedly a *Neothais*, having the form of *scalaris*. There is, however, some doubt concerning the spiral ribbing, for the fossil seems to have the spirals more numerous and not so coarse; but its surface is considerably worn.

Specimen in Mr. Fleming's collection.

**Cylichnina segnis** n.sp. (Fig. 41).

Shell small, solid, barrel-shaped, spiral sculpture not evident. Its relationship seems to be with *C. soror* (Suter) and *C. enucleata* Powell and Bartrum. It is broader across the summit than *soror* and has a wider perforation than either of them. It is not so short and stumpy as *enucleata*. It has the same heavy plait as *soror*, but the groove behind this is better defined. Below the plait and at the base of the columella there is a denticle which is somewhat elongated obliquely across pillar, and resembles a second and weaker plait. This is not present in *soror*.

Height, 2.8 mm.; width, 1.4 mm.

Two specimens collected.

**Philine constricta** Murdoch and Suter.

This may be distinct from *constricta*, but in the absence of specimens of Recent shells, it is left under Murdoch and Suter's name. Two specimens.

**Dentalium** n.sp.

This record is based on a single small specimen. It is akin to a new species allied to *D. nanum* Hutton occurring in Awamoan beds at Target Gully and at Ardgowan. The ribs are eight in number (nine in the South Island form), thin, sharply elevated and widely separated one from the other by flattish grooves. New record.

## New Zealand Foraminifera: Key Species in Stratigraphy, No. 4.

By H. J. FINLAY, D.Sc.

(Government Micropalaeontologist, Wellington).

[Read before the Wellington Philosophical Society, August, 1939; received by the Editor, September, 1939; issued separately, March, 1940.]

As in the previous parts, "CCL" stands for *Contributions to the Cushman Laboratory for Foraminiferal Research*, localities mentioned more than once are referred to by numbers with explanatory list at end, only the largest dimension is given, and co-types have been forwarded to the Cushman Laboratory (Sharon, Mass.) and to the Parr collection (Melbourne).

**CONOTROCHAMMINA** n.gen. (Fam. Ammodiscidae).

Genotype: *C. whangaia* n.sp.

An arenaceous isomorph of *Fischerina*—a tubular cone divided into chamberlets, with constricted aperture in centre of terminal face. *Trochammina* applies to depressed *Discorbis*-like forms with aperture at base of last chamber; the present form is wound like *Turrispirillina* and bears somewhat the same relation to *Trochamminoides* as *Ammodiscoides* does to *Ammodiscus*.

**Conotrochammina whangaia** n.sp. (Plate 62, figs. 1, 2.)

Coarse sand grains in little cement, wound in compact rapidly descending spiral, about as high as wide; 2-3 coils, about 6 chambers in each, marked only by faint constrictions, all sutures very obscure, not interrupting outlines. Umbilicus deep, up to third of width. Aperture a tiny circular opening at centre of terminal face and only a fraction of its area. Size, 1mm. each way.

Type from 5374; index of Whangai. Not seen in Lower Rakauaro or type Piripauan, but present in the Waitangi *Rzehakina* Red Shales. The only specimens clearly showing chamber constrictions and aperture are from 4050, Waipawa Black Shale, where they are abundant but distorted.

**Cyclammina grangei** n.sp. (Plate 62, figs. 3, 4.)

Fine cement, no large grains, white, smoothly finished, shining; edge acutely angled. Outer half gently sloping to this edge, inner half suddenly swollen round distinct narrow umbilicus, giving a crater-like effect. 10-11 chambers, radial sutures grooved, sometimes faintly sigmoid; internal labyrinth apparently of simple type, showing through on surface as 5-6 equidistant dark lines projecting forwards from sutures about a third of way across chambers; the alternation of short white and dark lines very marked when surface is moistened, simulating retrol processes of *Elphidium*. Apertural face with coarser grains, a little roughened, without opening at periphery. Size, 0.7 mm.

Type from 5338, Lower Bortonian. Common at this horizon in North Island, but present also in Upper Bortonian and Piripauan.

***Siphotextularia kreuzbergi* n.sp.** (Plate 62, figs. 5, 6.)

1930. *Bolivina hantkeniana*, Kreuzberg, *Neuen Jahrb. für Min.*, etc., Beil. Bd. 64, Abt. B, p. 278, pl. 20, fig. 6; non Brady.

Very fine sand-grains in much cement, smoothly finished, darker and coarser posteriorly. Much compressed, expanding rapidly from sharp apex at 90° for about one-third of shell, then sides sub-parallel. Greatest thickness (about one-third width) at half-way, bevelled in all directions to acute slightly thickened flange surrounding whole shell, a little wing-like anteriorly. About 7 pairs chambers with small spiroplectine apex, progressively less embracing, lower parts a little bulbous, sutures deep, 20–30° from horizontal. Aperture a little rounded tube springing from flange almost at base of chamber. Size, 0.75 mm.

Type from G.S. 1240, Upper Ihungia. Rather rare, seen mostly in Hutchinsonian; Kreuzberg's examples were from the (probably Lower) Ihungian of Whakatu Stream, left tributary of Waiapu River, Mangaoporo S.D. One occurrence known in the Tutamoe (Awamoan) of Pourerere S.D. (5845) with *Siphogenerina pohana*.

***Siphotextularia ihungia* n.sp.** (Plate 62, figs. 7, 8.)

Fairly fine sand-grains, not much cement, smoothly finished, darker and rougher posteriorly. Expanding from sharp apex regularly at about 70° and rapidly thickening to half of width (resembling *S. acutangula* Finlay; previous number, p. 310); sides sharply serrate for whole length. 9–10 pairs chambers, considerably embracing, all but last 2 about 4 times long as wide, fairly convex with deep sutures at slight angle from horizontal; last 2 much inflated at sides, flattish on top. Aperture an elongate spout, nearly halfway up face, with well-raised rim. Size, 0.9 mm.

Type from G.S. 1240, Upper Ihungia. Same rarity as the allied *kreuzbergi* but much thicker, not flanged anteriorly.

***Siphotextularia subcylindrica* n.sp.** (Plate 62, figs. 9, 10.)

Very small, rather fine sand-grains in much cement, brownish. Expanding very quickly from blunt rounded apex, then sides sub-parallel over three-fourths of shell; thickness almost similarly increasing to three-quarters of width; flattened down front, sides broadly rounded. First chambers obscure, about 6 pairs visible, flattish, with shallow sutures; last 2 subtriangular, flattened at about 45° on top. Aperture an elongate slit, about one-third length of terminal face and a quarter way up it, bordered by thin raised rim all round. Size, 0.55 mm.

Type from 5703, base of Upper "Blue Bottom," Callaghan's Creek, Waimea S.D., Westland; not uncommon in Tongaporutuan and Urenui beds. Index of Taranakian.

***Eggerella columna* n.sp.** (Plate 62, figs. 14, 15.)

Fine and coarse sand-grains in much cement, surface slightly roughened, almost perfectly cylindrical, polyserial apex very bluntly rounded, not marked off from remaining coils (about 3) of non-inflated triserial chambers; sutures hardly visible, spire outlines little interrupted; last 3 chambers sub-globular, much flattened on

top, sutures deepening towards depressed centre. Aperture a very tiny circular opening at centre. Size, 1 mm.

Type from 4012, bentonitic shale of Red Shale Stream, Waitangi Hill Road, with *Rzehakina*. Only known from this Uppermost Cretaceous horizon. No described species is at all as cylindrical.

*Eggerella ihungia* n.sp. (Plate 62, figs. 11-13.)

Fine and coarse sand-grains in much cement, smoothly finished, brownish, not quite twice as long as wide, bluntly pointed; polyserial chambers obscure, rather more than a third of shell; about 2 coils of triserial chambers, little inflated, sutures shallow, indistinct anterior join of last 3 chambers flattened off at angle of 30°, central point hardly depressed, aperture an obscure narrow chink somewhat off centre. Size, 0.8 mm.

Type from 5390, Rotokautuku Creek. Also in 5242, Takapau S.D. and 5056 Terakohe Quarry, but otherwise rare. Index of true Hutchinsonian. Related to the Arctic *E. advena* (Cush.), which is longer and has much deeper sutures and far more chambers.

*Dorothia elongata* n.sp. (Plate 62, figs. 16, 17.)

Finely arenaceous, much cement; irregular numerous grains so neatly fitted and flush with surface that almost invisible. Surface faintly shining, dull white, smooth. Initial triserial part a little swollen, very small, sutures indistinct; biserial part 5-6 times as long, a little twisted; chambers about 6 pairs, progressively more inflated and with deeper sutures (and thus more lobulate shell outline) a little flattened at about 30° anteriorly; median sutures not plain, weaker than sub-horizontal side ones. Aperture rounded, about half as high as slanting 45° terminal face. Shell in general about midway between *Gaudryina whangaia* Fin. (previous number, p. 311) (similarly white but larger, without initial sharp angles) and *Karrerella cushmani* Finlay (see later) (darker, with pronounced polyserial part and spout aperture). Size, 1.2 mm.

Type from 5372, Weber bridge, 1 m. S.E. of Weber; Whangai. Index of Piripauan; sometimes the only recognisable species in the poorly fossiliferous argillitic part; one of the best and most persistent key species of this age. It has not been seen in company with *Gaudryina whangaia*, and it is possible that the *Rzehakina* Piripauan strata are divisible into a lower horizon (with *D. elongata* and *Gaudryina healyi*) and an upper (with *G. whangaia* and *Conotrochammina whangaia*). With belemnites in 5311, base of Katiki Beach section, but not in Danian Moeraki beds above. Evidently a close relative of the European Cretaceous *pupoides* d'Orb., which has subglobular chambers and deep sutures.

Genus *KARRERIELLA* Cushman, 1933 (Fam. Valvulinidae).

Subgenus *KARRERULINA* n.subgen.

Genotype: *Gaudryina apicularis* Cush., 1911 (*U.S. Nat. Mus. Bull.*, 71, pt. 2, p. 69); new name for *siphonella* of Brady (*Chall. Zool.*, vol. 9, pl. 46, figs. 17-19.), non Reuss. Indo-Pacific and East Coast of U.S.A., in deep water.

This species has been discussed and fully figured by Cushman (*CCL Special Pub.*, No. 8, p. 110, pl. 12, figs. 22-26, 1937) and placed

in *Plectina* because of the terminal aperture. Two other species there discussed seem congeneric:—*Karreriella postsiphonella* (Span-del) (*ibid.*, p. 127, pl. 15, fig. 9) and *Dorothia* (?) *conversa* Grzyb., as figured, in part at least, by Jedlitschka (*ibid.*, p. 79, pl. 13, figs. 1-4).

These all differ from *Karreriella* in having a quite terminal aperture formed by a constricted prolongation of last chamber (instead of a narrow-walled more or less compressed spout usually set in an excavated area near base of last chamber, which rises above it as in *Siphotextularia* Fin.). *Plectina* has a sunken aperture without spout.

***Karrerulina bortonica* n.sp.** (Plate 62, figs. 18-20.)

Closely related to *apicularis* but less than half size, with bluntly rounded base and obscure triserial chambers; about 4 times as long as wide, with 4-5 pairs biserial chambers (more than in Recent species, although smaller shell); of coarse material with indistinct sutures except on last half. Size, 0.8 mm.

Type from 5338, Lower Bortonian. Common here, less so in Upper Bortonian, and increasingly rare in Kaiatan, and perhaps later; not seen in Cretaceous.

In the Danian and Lower Bortonian is *Karrerulina aegra* n.sp. (plate 62, figs. 21, 22, 25, 26), somewhat smaller, more slender, 4-5 times as long as wide, with smaller and much less bulbous triserial part. Chambers obscure, sutures hardly affecting spire outline; of rather coarse grains smoothly set in much cement, surface slightly rough. Size, 0.6 mm. Type from 5746, upper Moeraki Beds below Hampden Bortonian (Wangaloan). A still earlier species is *Karrerulina clarentia* n.sp. (plate 62, figs. 23, 24), common in the Raukumara, smaller than the others and still more slender, 5-6 times as long as wide, 6-7 pairs vertically compressed biserial chambers with rather deep sutures interrupting spire outline all over; very small triserial part. Size, 0.6 mm. Type from 5375, Porangahau S.D., 1 m. at 165° from Trig D; Raukumara Beds. Other Cretaceous and Tertiary species are known.

***Karreriella novozealandica* Cushman.**

1936. *Ibid.* Cushman, *COL Special Pub.*, No. 6, p. 37, pl. 5, figs. 18a, b.

1937. *Ibid.* Cushman, *COL Special Pub.*, No. 8, p. 133, pl. 15, fig. 9.

This was described from "Miocene of Motutara," a very vague locality. Parr\* (*Journ. Roy. Soc. W.A.*, vol. 24, p. 88, 1938) has stated that *Nonion novozealandicum* Cush. (which was similarly localised) was from the "Lower Oligocene of Motutara Point, Kawhia Harbour." In passing, it may be mentioned that this species is a synonym of *Nonion maoricum* (Stache), described (as *Rosalina*) from the type Whaingaroa beds (*Novara Pal.*, vol. 1, p. 282, pl. 24, fig. 32, 1864). The Motutara beds are of Whaingaroan age, now placed as Mid-Oligocene. *K. novozealandica* does not range above this (5047,

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\*In a recent letter Mr Parr informs me that Cushman's material labelled "Motutara" and "Kawhia" was purchased in France, and that similar material bought in Melbourne came originally from Tempere's French collection and contained all the characteristic Motutara species.

5577, etc), but is not uncommon in the Kaiatan (e.g., 5680) and continues back to Lower Bortonian; no true *Karreriella* is known from our Cretaceous. Bortonian examples (from 5382) are here figured (plate 63, figs. 35-37) to show the rather stout habit, somewhat compressed shell, about 8 biserial chambers, convex terminal face and short bulbous polyserial part.

In the Waitakian, Hutchinsonian and Awamoan, the common form is *Karreriella cushmani* n.sp. (plate 63, figs. 38-42), considerably more attenuate, still lightly compressed with deep sutures and lobulate outline, but about 12 pairs biserial chambers, more elongate and detached, a flattened end face, and longer less bulbous polyserial part. Size, 2.1 mm.; type from G.S. 1240, Upper Ihungia.

In the Taranakian is evolved a form, *Karreriella cylindrica* n.sp. (plate 63, figs. 43-46), which lasts till the Waitotaran (2102); large and elongate like *cushmani*, but much more compact, with little inflated chambers, shallow sutures, a cylindrical shape and hardly lobulate outline, polyserial part relatively much more pointed, not bulbous but spirally merging up into adult chambers. Size, 2.1 mm. (Pliocene examples smaller); type from 5557A, Tongaporutuan. This form has already been figured, under the name "*Karreriella siphonella* (Reuss)," by Parr (*Trans. Roy. Soc. N.Z.*, vol. 65, pt. 2, p. 84, pl. 20, fig. 3, 1935), from the Taranakian of Medway River.

*Nodosaria subtetragona* n.sp. (Plate 63, fig. 47.)

Extremely close to *tetragona* Costa as figured by Cushman and Jarvis, 1930 (*Journ. Pal.*, vol. 4, no. 4, p. 360, pl. 33, fig. 1), but widening more rapidly and somewhat twisted. No complete adults yet found; proloculum sub-oval, bluntly pointed, next chamber shorter, narrower and squarish, rest oblong, becoming about twice as long as wide, a gradually broadening very thin flange running up each side, about equal to width between the two other ribs, which are much lower and run up centre of shell equidistant from themselves and flange, slightly lower at sutures; first 3 or 4 chambers with slight twist, rest of surface usually quite smooth; senile shells with a few extra riblets. Size, 2.2 mm.

Type from G.S. 1342, Tutamoe. Ranges from Upper Ihungia to Taranakian.

A related form from a higher horizon is *Nodosaria sinalata* n.sp. (plate 63, fig. 49). This is identical in the early stages, having same proloculum, early chambers and twist, but is more slender and chambers lengthen more rapidly to 5-6 times their width; chief difference is loss of side flanges and more numerous ribs; 8 equal slender ridges about 3-4 times width apart; size 2.2 mm. Type from 5561, Waitotaran. Ranges from here down to Tongaporutuan, where it accompanies *subtetragona*. The Pliocene Indo-Pacific *tosta* Schwager is closely related, but has only 6 costae (see Cushman, 1939, *Trans. Pal. Soc. Japan*, vol. 14, no. 14, p. 149, pl. 10, fig. 2).

A still more costate form is *Nodosaria* (?) *multicostales* n.sp. (plate 63, fig. 48) with flange each side and seven subequidistant ridges between, others intercalated later; differing from *subtetragona* also in much more arched sutures and much slighter twist; size,

1.5 mm. Type from 5207, Eketahuna mudstone; apparently restricted to Opoitian. This is transitional to *Fronicularia* and might be better referred there.

***Amphicoryne prora* n.sp.** (Plate 65, figs. 148, 149).

Differs at sight from the Recent *A. falx* (J. and P.) in absence of sculpture, subspherical last two chambers, more elongate and prow-shaped initial part with sharp keel curved almost at right angles to a point jutting beyond sides; 8 or more long narrow chambers in vaginuline part; aperture a thick tube, without rings. Size, 0.9 mm.

Type from 5273, Awamoan. Known from Whaingaroan (1279); rarity makes upper limit uncertain.

***Gumbelina panikauia* n.sp.** (Plate 63, figs. 53-55.)

Smooth, with few chambers, apex rather blunt, width and spherical chambers at first rapidly increasing then less so, sides of last 4 sub-parallel; last sometimes smaller, about 5 pairs with deep distinct sutures; aperture relatively small, without lip or ears joining previous chamber, surface quite smooth and shining. Size, 0.4 mm.

Type from 5698; Piripauan index. *G. globulosa* (Ehrenb.) is similarly smooth, but has much more acute apex with 6 chamber pairs, a large widely gaping aperture and little tendency to alter taper anteriorly. The European species is common in the West Australian Gingen Chalk and is readily separable from *panikauia* in aperture alone.

A species also with about 5 pairs of chambers is ***Gumbelina ototara* n.sp.** (plate 63, figs. 50-52), common in the Oligocene (type from 5182; Kaiatan. Size, 0.23 mm.); chiefly distinguished by minute size, smooth compact shell, and little separated chambers.

***Bolivinoidea dorreeni* n.sp.** (Plate 63, figs. 56-58.)

Sub-diamond shaped, increasing regularly in thickness to aperture end; apex a little swollen by rather large proloculum, sides angled with fairly sharp, slightly serrate edge, anteriorly flatly rounded; 8-9 pairs of chambers, sloping at 45°, narrow faintly curved sutures obscured by ornament, a medial almost grooved area formed by 2 ribs running up centre, slightly diverging and strongest basally. 4 narrow raised ridges prominently cross excavated spaces between thickened tops of chambers at right angles to sutures, approximately continuous. Aperture a short narrow slit at right angles to base of chamber. Size, 0.5 mm.

Type from 5698; Piripauan index. Related to *decorata* Jones and *delicatula* Cushman, but with much more distinct fenestrate sculpture, due to the stronger narrow ridges.

***Rectobolivina hangaroana* n.sp.** (Plate 63, figs. 59-61.)

Large, stout cylindrical, slightly compressed. Micro form tapering to blunt point; 8-9 biserial chambers then unknown number of uniserial. Megalo form hardly tapering, with swollen apex formed of large proloculum and 3 biserial chambers; after slight constriction 6 uniserial chambers follow; whole shell covered by very fine, dense ridges with linear interstices continuous across sutures and giving

appearance of fine striation; chambers gradually increasing in height, last one longer, constricted a little to rim round large oval aperture. Size, 1.1 mm. (megalo type); 0.88 mm. (micro paratype).

Type from 5018; index of Upper Poha (Urenuian?); also in 3114, Waimata S.D. Related to *columellaris* Brady, especially the variety *semistriata* Schubert, but more densely and completely striate, with fewer and less inflated chambers. The reference of such forms to *Siphogenerina* seems a mistake; there is nothing in common with *costata* Schlumb., but much with *bifrons* Brady.

**Bulimina miolaevia** n.sp. (Plate 64, figs. 70, 71.)

Miocene representative of the Eocene *bortonica* Finlay; similarly smooth all over, but much larger, with less inflated, more closely knit chambers; spire outlines less lobulate, almost straight; aperture shorter, not cutting across base to form notch on opposite side, a few faint indentations in horizontal suture at beginning of each chamber sometimes present. Size, 0.9 mm.

Type from 3013, Whangara, Middle Ihungia. Usually rare, but common in the true Hutchinsonian of Pourerere S.D. (5347, 5858). Index of Hutchinsonian. A Whaingaroan form (5681) is close.

**Bulimina mapiria** n.sp. (Plate 64, fig. 72.)

A nearly smooth form with strong apical spine, spire with marked twist, chambers rapidly descending, not numerous, somewhat elongate, the last narrowing to blunt angle anteriorly; sutures distinct but very shallow; early third of shell with numerous irregular costae merging posteriorly into strong sharp spine, rapidly dying anteriorly, last volution and most of previous one smooth. Size, 0.6 mm.

Type from 5018; common in the Mapiri and elsewhere at this Upper Poha horizon, together with *Bolivinita compressa* Finlay.

**Bulimina rakauroana** n.sp. (Plate 64, figs. 75, 76.)

An *aculeata*-like form of large size with apical spine, chambers lightly inflated, smooth except for a row of numerous short spines on shoulder just below suture, crossed by faint groove, producing a doubled effect, faint traces of costae on earlier chambers, horizontal sutures deeply cut, forming staged spire, aperture large. Size, 0.8 mm.

Type from 3270, Lower Rakauroa; index of Piripauan. Very close to *midwayensis* C. and P. (*CCL*, 12, 2, p. 42, pl. 7, figs. 9-10, 1936), which has inflated chambers and stronger spines further down on chambers, without groove. Even closer to the Californian Cretaceous *spinata* C. and C. (*l.c.*, 11, 3, p. 72, pl. 11, fig. 11), but relatively longer and less inflated.

**Bulimina senta** n.sp. (Plate 64, figs. 73, 74.)

A development of the *inflata* type, in which spire chambers are closely appressed and not much descending, costae greatly weakened but developing short, strong, downward pointing, blunt spines on shoulder of each chamber, the rather distant spikes jutting from points some two-thirds of chamber width from previous suture. Apex with a long, strong spine; last 3 chambers making up more than half shell, practically smooth, except for spines. Size, 0.7 mm.

Type from G.S. 1342, Waikura Stream, Tutamoe. Ranges from Hutchinsonian (5347) to Lower Taranakian (3151).

**Bulimina truncanella** n.sp. (Plate 64, figs. 89-91.)

Tiny, triangular, about twice as long as broad; sides sub-parallel, rapidly tapering near apex to sharp point, but no spine; apertural end obliquely truncate at about 40°, chambers indistinct, not inflated, overridden by heavy sculpture of sharp, linear ridges, about 18 in number, continuous from apex to just on to base of last chamber, sub-equidistant but arranged roughly in threes, a rather stronger triplet down each blunt angulation with 2 to 3 on sides between, last chamber mostly smooth. Size, 0.27 mm.

Type from 5540, Hampden section; Lower Bortonian. More or less common from here to Tongaporutuan (3137). Evidently related to *truncana* Gumbel (see CCL 13, 3, p. 66, pl. 9, fig. 3, 1937) but much smaller, less inflated and with far more costae.

A form extremely like *truncana* does, however, occur in the North Island Hutchinsonian-Awamoan, **Bulimina bremneri** n.sp. (plate 64, figs. 84-86), differing apparently only in slightly more trigonal section and more inflated chambers leading to distinct cut-in sutures, stepped appearance between ridges, and less pointed and tapered apex; twice size of *truncanella* (0.4 mm.) with about 12 heavy costae; type from 5033, Patutahi S.D. (1½ m. n. 75° W. from Trig XII), Upper Ihungia; also in Tutamoe.

**Bulimina forticosta** n.sp. (Plate 64, figs. 77-81.)

Like American Eocene *jacksonensis* Cush. (see U.S.G.S. Prof. Paper 181, p. 35, pl. 13, figs. 7-9, 1935), but less elongate, widening rapidly, slightly sub-triangular in section with 11-12 strong costae, instead of 6-8; number and style of ribs very like *truncana* Gumbel, but aperture and chamber formation of *jacksonensis* style. The Oligocene *sculptilis* Cushman, has 10 costae, but is elongate. Size, 0.7 mm.

Type from Waitangi No. 1 Well Core (Core 9, no. 3), 750 ft.; Upper Bortonian. Also present in Point Elizabeth beds (5359); Whaingaroan.

**Bulimina pahiensis** n.sp. (Plate 64, figs. 87, 88).

Triangular in section; keels sharpening towards pointed but not spined apex, blunted anteriorly, where sides become sub-parallel; chambers indistinct, sutures almost flush, whole upper surface covered by fine vertical ridges, sharp but very close and barely visible, slightly twisting as they descend; an indentation in upper posterior suture of each chamber, last few chambers becoming smooth. Size, 0.6 mm.

Type from 3310, Pahi marl. Index of Upper Bortonian; related to the Midway *cacumenata* C. and P. (CCL, 12, 2, p. 40; pl. 7, fig. 3, 1936), but much larger, with sharper keels and finer striae. The Aragon *semicostata* Nuttall is as large, but has much coarser ornament.

An Upper Oligocene relative is **Bulimina scobinata** n.sp. (plate 64, figs. 82, 83), also sub-triangular, with rounded keels, distinct but shallow sutures, a twisted spire and sub-circular little inflated chambers, finely roughened or shagreened all over by minute pitting; size, 0.9 mm.; type from 5093 Porangahau S.D. (also 5275, Kawa-Kawa Trig, and 1005). This much resembles the Trinidad Eocene

*jarvisi* C. and P. (*l.c.*, 12, 2, p. 39, pl. 7, fig. 1, 1936), but has no fine costae. It also occurs in the Poverty Bay Maungatapere formation (Whaingaroan), at Waikura Stream (5365).

**Cassidulina cuneata** n.sp. (Plate 63, figs. 62-66.)

Irregularly wedge-shaped, angled round aperture, bulbous posteriorly, 4 triangular chambers round a central square visible in front view, each suture bisecting next and running straight across surface; 4 also in back view, the upper (largest) triangular with a squarish sub-globular one below, with smaller ones each side. Aperture large and gaping, semicircular, the straight edge set at  $45^\circ$  to suture, with a strong, sharp, flat tooth projecting almost halfway across it from base. Size, 0.7 mm.

Type from 3137, Kaiti Beach, Poverty Bay, basal Taranakian. Enters commonly in Hutchinsonian and lasts to Urenuian; common throughout our Miocene, absent in Pliocene. Differs in sub-trigonal form from all our other species. Has been usually identified as *murrhyna* Schwager, but the original figure of that Indo-Pacific Pliocene species has no resemblance, especially in the aperture, which is chink-like, set in a produced beak-like last chamber, as in some forms of *subglobosa* (cf. the Antarctic *producta* Chapman and Parr, compared by the authors with *murrhyna*). Specimens from the basal Ouba formation (Upper Miocene), of New Guinea, in a fauna closely resembling that from Kar Nicobar are quite close to *subglobosa* and in no way resemble these N.Z. shells. But an Upper Mena fauna (Middle Miocene) from the same district contains a few specimens of an extremely similar species.

Except in the basal "Blue Bottom" of Westland (possibly still true Hutchinsonian) this form is uncommon in the South Island, where the apparently unsuitable facies makes its lower range limit uncertain. It has not occurred in the Waitakian of Cobden district, Mid-Waipara, or Weka Pass, but is present, with *Cibicides verrucosus* and *Marginulinopsis* aff. *hochstetteri* in a Hawke's Bay formation (5854, Mangaotero S.D.) which seems to be of this age.

**Nonion iota** n.sp. (Plate 65, figs. 108-110.)

Very similar to *N. micrum* Cole and *danvillense* Howe and Wallace (see Cushman, *U.S.G.S. Prof. Paper, No. 191*, p. 5, pl. 1, figs. 19-22, 1939); same small size and deep sutures as *danvillense*, but with the fewer chambers of *micrum*; more inflated chambers than either, leading to more lobulate periphery and more sunken umbilical area each side; shell usually more compressed with rounded periphery. Size, 0.25 mm.

Type from 5300, Upper Bortonian. Index of Lower Bortonian (5570) to Kaiatan.

**Nonionella magnalingua** n.sp. (Plate 65, figs. 144, 146.)

Of the *turgida* (Will.) style, but inflated, not compressed; perhaps nearest *jacksonensis* Cush. (*U.S.G.S. Prof. Paper, 191*, p. 29, pl. 8, fig. 2, 1939), but stouter, less elongate, with rounded base, much less coiling visible. About 8-9 chambers in the single coil, which is initially swollen and marked off by deep sutures and almost an umbilicus; last chamber continued up on one side as a very large swollen

tongue completely hiding spire, base widely rounded, in front view widest medially, axis of last chamber intersecting vertical axis at  $20^\circ$ ; size, 0.4 mm.

Type from 5124, Awamo Creek, type Awamoan. Seen also in Duntroonian (5699), fairly often in Taranakian, and finally in Waitotaran (5561). The Kai-Iwi and Recent form is distinct.

A longer ranging species is *Nonionella zenitens* n.sp. (plate 65, figs. 145, 152–156), of similar small size, general shape, and polished shining test, but with very feeble tongue, not reaching above margin of coil, which is but little immersed in it and is marked off by much feebler sutures, base sub-acutely rounded, sides much straighter; asymmetry obvious only in basal view. Recalls *N. extensa* Brotzen (Cushman, l.c., p. 28, pl. 7, fig. 7), but larger, more inflated, with converging not sub-parallel sides in front view and less visible coiling; size, 0.4 mm. Type from 5179A, Hampden, Upper Bortonian; lasting to Middle Miocene (fig. 145), where it occurs together with *mag-naliqua*, but apparently not present in Taranakian; extends down to Lower Bortonian (5570).

Of the same size and chambering but with still weaker tongue and stout shell is an offshoot *Nonionella satiata* n.sp., apparently confined to Awamoan; much more inflated at upper three-quarters, base still being broadly triangular, the still weaker asymmetry set at an angle of  $45^\circ$  to vertical, acutely rounded below in both side and front views, side opposite aperture much more convex. Type from 5124, Awamo Creek.

A Cretaceous development with tongue so reduced that symmetry is almost attained is *Nonionella tanumia* n.sp.; same size as *zenitens*, but early chambers curved well above aperture, which is conspicuously open and narrowly rounded like *Chilostomella*, base only about three-quarters length of shell instead of as long and bluntly instead of acutely rounded in both side and front views, basal sides more nearly parallel, extending only very slightly higher on one side. Type from 5860 (Tanumi Bridge, just overlying Waipawa black shale); confined to Piripauan.

#### ***Elphidium hampdenensis* Finlay.**

1939. *Ibid.*, *Trans. Roy. Soc. N.Z.*, vol. 69, pt. 1, p. 127, pl. 12, figs. 29, 30.

Figures, type locality, and range of this species have been given, but no diagnosis. It is fairly compressed, flattened and faintly excavate medially, with angled but not acute keel marked by a cord, one coil visible, with about 10 obscurely marked chambers, radial sutures ridge-like, strongly curved, 2–3 times width apart; spaces between with spiral ridges of about similar strength, about 7 per chamber; umbilical area tiny, with no ornament but the ridges; apertural face an isosceles triangle with slightly curved sides and openings at grooves along base. Size, 0.6 mm. Type from 5540, Hampden section; index of Lower Bortonian.

#### ***Elphidium saginatum* Finlay.**

1939. *Ibid.*, *Trans. Roy. Soc. N.Z.*, vol. 69, pt. 1, p. 127, pl. 12, figs. 31–33.

Very inflated, flat medially, with flatly rounded periphery; one coil visible with 8 chambers, radial sutures almost straight, weak,

marked mostly by retral processes; a few shallow grooves a short distance after each suture, central area a small depression with encircling blunt ridge surrounded by a circle of shallow coarse pits, one after each suture; apertural face sub-crescentic, with openings along base. Size, 0.5 mm. Type from 5459, Mangaotero S.D., 178 ch. at 74° from Trig U; index of Upper Bortonian, but not present at Hampden. Common in Hawke's Bay and Poverty Bay, associated with *Zeauvigerina zelandica* and other Upper Bortonian forms.

GENUS ANOMALINA d'Orb., 1826.

The first two species described below belong to the coarsely perforate group of "*grosserugosa* Gumbel," *rubiginosa* Cush., *dorri* Cole, etc., but the others have a superficially different appearance. The aperture and shell development, however, seem essentially the same, and no constant point has been observed to allow of even subgeneric separation. Some of the species resemble such gyroidine types as *Rotaliatina*, but are distinctly perforate, while *Gyroidina* and its allies have such minute pores that the surface appears quite smooth; the anomaline aperture is also more widely open, with usually a better developed lip and nearly always extends well over on to the dorsal side and back along the spiral suture. If the *dorri* group were split off on the basis of pore size, *Cibicides* would also need division on this count, and the utility of this is doubtful.

**Anomalina visenda** n.sp. (Plate 65, figs. 116-119.)

Shell large, inflated, dorsally 2 coils visible, ventrally involute with deep umbilicus; 8 chambers in last coil, swollen with distinct but not deep sutures, periphery flatly rounded; heavily ornamented above and below by intersecting diagonal ridges, producing pitted surface, like very coarse *Globigerina*. Centrally this ornament coalesces into regular, raised smooth patches dorsally and heavy rugae ventrally; anteriorly ornament weakens, last chamber with smaller pits and punctae. Periphery slightly smoother, terminal face quite smooth, aperture normal. Size 1.1 mm.

Type from 5371, type Wanstead, Upper Bortonian. Also in Lower Bortonian (5570); not seen below or above this. Related to the Mexican Lower Eocene *aragonensis* Nuttall, which has much coarser and more distinct pitting, especially ventrally.

Another species of this line is **Anomalina aotea** n.sp. (plate 65, figs. 111-115), which is smaller with rather fine pitting dorsally and smooth shining ventral surface, without medial coalescence or rugae. Last chamber practically smooth all over, 6-7 in last coil. Size, 0.5 mm. Type from 5179B, Hampden, Upper Bortonian. This has a much longer range, extending also into Piripauan and throughout lower Tertiary. Large specimens, perhaps a little more lobulate, occur commonly in the Weber (5835), Oxford Chalk (5047), and other Whaingaroan strata, but are not easily separable even from Piripauan forms (5301, 3270). This may be the upper limit of *aotea*.

**Anomalina vitrinoda** n.sp. (Plate 65, figs. 120-122.)

Compressed, periphery acutely rounded, flattish above and below. Ventrally involute, smooth and shining, sutures strongly curved at

outer two-thirds, then flush; dorsally with  $1\frac{1}{2}$  visible coils, 13 chambers in last, sutures lightly curved, heavily limbate, spaces between and central knob coarsely punctate. Umbilicus filled by glossy knob above and below. Aperture like *Cibicides*, narrowly rounded on periphery, sharply limited ventrally, continued back along dorsal suture with thin lip, remnants from previous chambers projecting as little ears over suture. Size, 0.6 mm.

Type from 5089, Eason's Hill "Blue Bottom," Westland; true Hutchinsonian. Common from here to Tongaporutuan (often seen in Taranaki beds). Ranges down to Whaingaroan (1279, 1281, Waitetuna Estuary); examples from here may be Stache's *Kosolina orbiculus* (*Novara Pal.*, vol. 1, p. 285; Pl. 24, f. 34; 1864), but it will be better to use a definite name until his types can be re-examined, since his figure resembles several species.

A distinct relative in Bortonian, *Anomalina semiteres* n.sp. (plate 65, figs. 123-127), is less compressed, planoconvex, the almost flat base similarly smooth and shining, dorsal punctation finer and denser, radial sutures increasingly limbate near inner margin of coil and projecting as blunt points into groove between coils (which are more visible ventrally), dorsal knob somewhat broken into pustules, about 11 chambers per coil; size, 0.5 mm. Type from 5179B, Hampden, Upper Bortonian; not in Lower Bortonian; ranging into Kaiatan (5601, etc.), but no higher.

*Anomalina miosuturalis* n.sp. (Plate 65, figs. 128-131.)

Very compressed, periphery bluntly narrowly angled, bevelled each side, a little flatter on top than below. Ventrally involute, with moderate umbilicus; dorsally with  $1\frac{1}{2}$  visible narrow coils, 15-16 chambers in last, sutures strongly curved, slightly and evenly limbate. Surface finely and densely punctate. Aperture with lip running from umbilicus, especially prominent round periphery and back along spiral suture for up to half a coil. Size, 0.5 mm.

Type from 5707, upper part of Middle "Blue Bottom," Eight-mile Creek, Hohonu S.D., Westland. Common in Miocene; entering in Duntroonian (5660) and ending in Awamoan.

A close relative common in the Eocene is *Anomalina eosuturalis* n.sp. (plate 65, figs. 132-137), differing only in indistinct radial sutures (broadening and poorly marked), fewer chambers (about 13), less curved sutures and obscure central portion, much more encroached on by last coil and lip. Size, 0.6 mm. Type from 5068A, Burnside marl; Tahuian. Ranges from Lower Bortonian (5540) to Whaingaroan (1279, 5047).

*Anomalina subnonionoides* n.sp. (Plate 66, figs. 172-180.)

Inflated, almost symmetrical, periphery very broadly rounded. Dorsally and ventrally involute with fairly wide, deep umbilicus filled by thickening of spiral suture as in some *Nonion* species; 1 visible coil, 10-11 chambers, densely punctate, aperture wide with prominent lip continued into ventral umbilicus and prominently running back for some 3-4 chambers along dorsal spiral suture; end face almost bisected by earlier periphery, but a little deeper and more convex ventrally. Size, 0.6 mm.

Type from 5273, Awamoan; common in Miocene. Connects up this group with the symmetrical *Nonion* at one extreme, while the compressed very asymmetrical species almost connect with *Cibicides* at the other. It would be a very slight step to develop this form from such a *Nonion* as *soldani* d'Orb. or *halkyardi* Cush. Related to the Recent Australian *nonionoides* Parr (*P.R.S. Vict.*, vol. 42, pt. 1, N.S., p. 231, pl. 22, fig. 38, 1929), but thicker, less coarsely perforate, and without the lobulate periphery. Ranges from Duntroonian (Chatton) to Awamoan.

***Anomalina spherica* n.sp.** (Plate 66, figs. 166-171.)

Very globose, simulating *Rotaliatina*, periphery broadly rounded, gently curved above, very convex below. Ventrally involute, very deep, narrow umbilicus with flatly rounded margin; dorsally with about 3 visible coils, 7-8 chambers in last, sutures fairly straight, not limbate; surface finely and densely punctate. Aperture narrow, long, with prominent lip merging into umbilical margin below, usually not reaching spiral suture above, but sometimes running back along it a little. Size, 0.5 mm.

Type from N. of Hen and Chickens in 30 f. Not uncommon during Pliocene (e.g., 4317 basal Opoitian), rare in Taranakian (5703, 5645), not seen earlier. Has only superficial resemblance to *Rotaliatina*, the texture, type of aperture and terminal face all disagreeing with *sulcigera* and like the other *Anomalinas* here described.

***Anomalina pinguiglabra* n.sp.** (Plate 66, figs. 160-165.)

Fairly inflated, periphery very convex, flattish on top, convex below. Ventrally involute with narrow, deep umbilicus; dorsally with large proloculum and nearly 2 visible coils, 9 chambers in last, sutures lightly curved, not limbate; surface finely punctate. Aperture wide, margined by prominent lip continued into umbilicus and back along spiral suture for 1 chamber. Size, 0.6 mm.

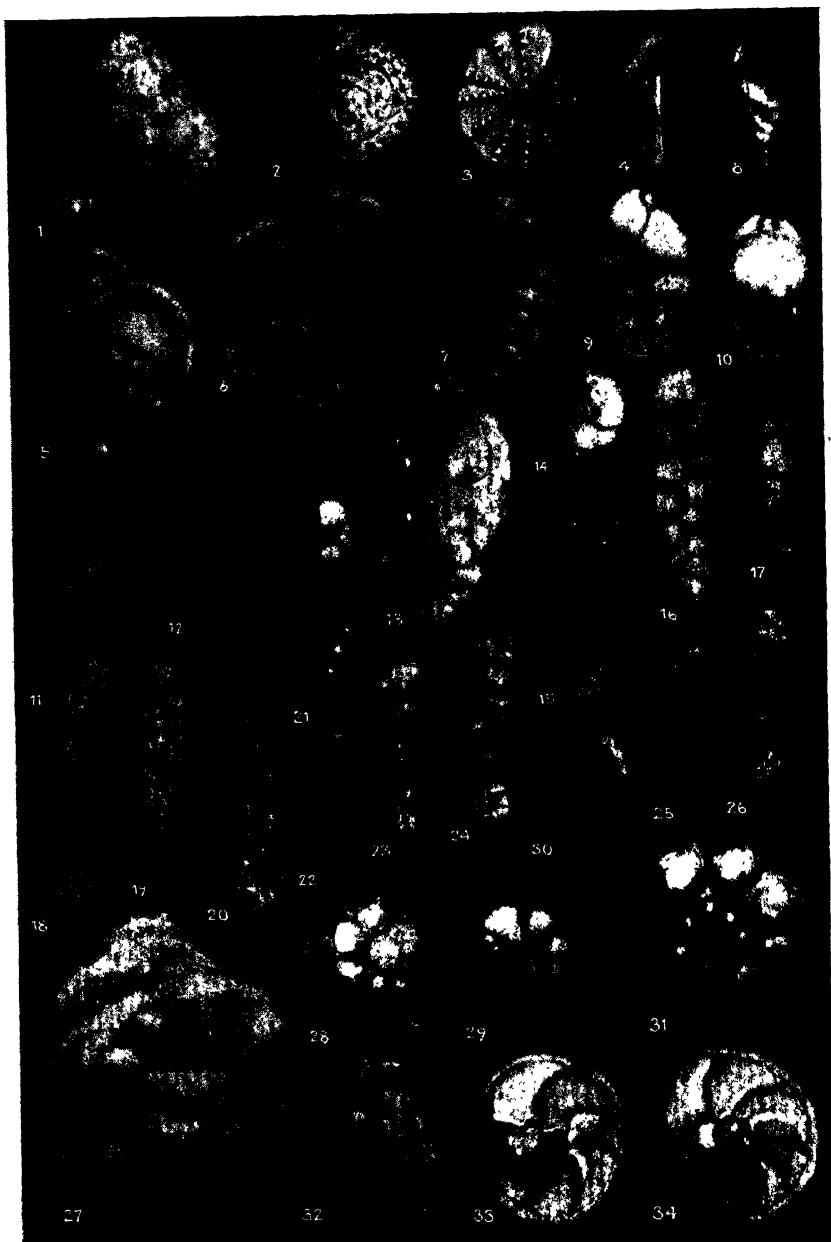
Type from 5273, Awamoan. Stands halfway between *macraglabra* and *spherica*. Ranges from Duntroonian (Wharekuri) to Awamoan.

***Anomalina macraglabra* n.sp.** (Plate 66, figs. 141-143.)

Moderately compressed, periphery bluntly angled, flatly convex on top, flatly convex below. Ventrally involute, with narrow not deep umbilicus; dorsally with 3 visible coils, 10-11 chambers in last, sutures strongly curved, not limbate, surface finely punctate. Aperture narrow, with marginal lip running into umbilicus and round periphery, but not back along spiral suture. Size, 0.57 mm.

Type from 5273, Awamoan; common in Hutchinsonian-Awamoan. Has been referred to as *glabrata* Cush., but topotypes of that Recent Samoan species, though with same chambering, are dorsally depressed, with wide umbilicus mostly plugged, coarser punctae, and a lobulate periphery. Begins in Duntroonian (5660) and lasts in abundance to Awamoan.

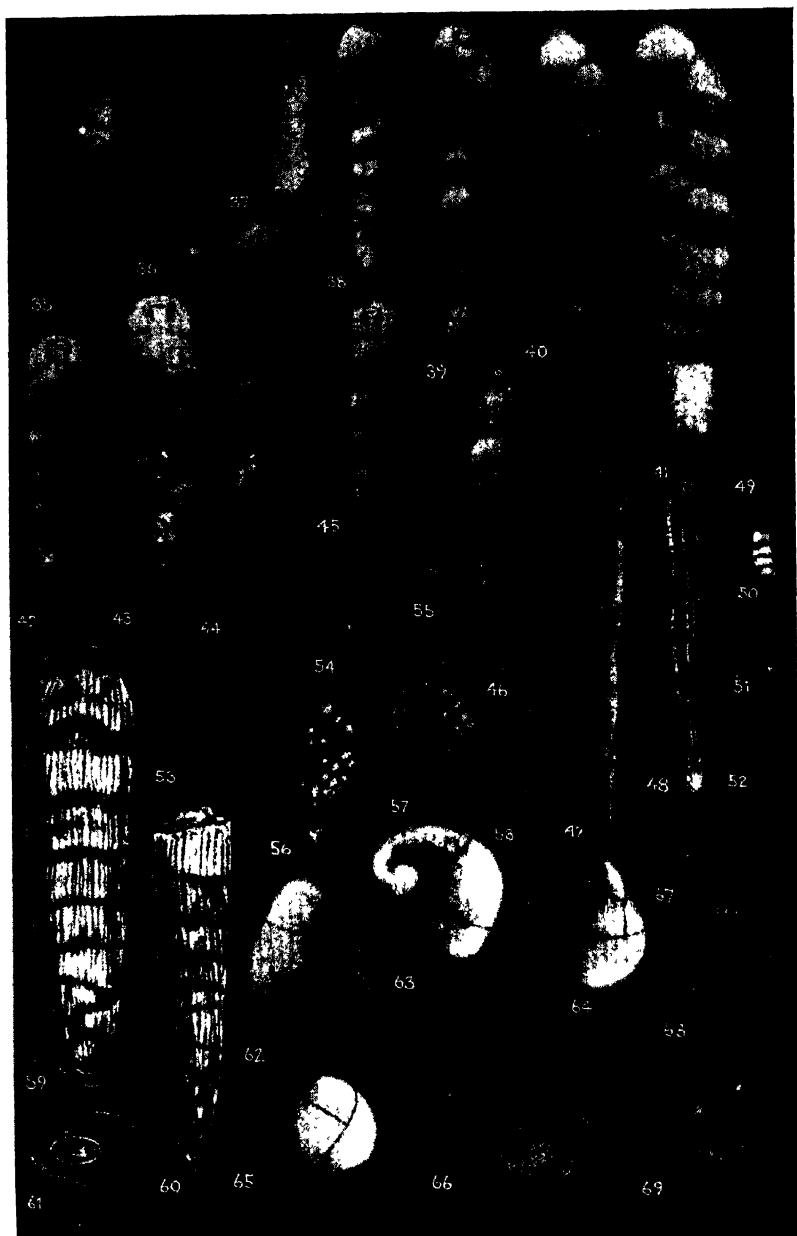
Of same style is *Anomalina eoglabra* n.sp. (plate 65, figs. 138-140) from the early Tertiary; general proportions and coiling same but smaller, with 13-15 chambers in last coil, dorsal sutures



FIGS. 1, 2—*Conotrochammina whangai* n.gen. n.sp. (1, type).  $\times 30$ . FIGS. 3, 4—*Cyclammina grangei* n.sp. (3, type).  $\times 30$ . FIGS. 5, 6—*Siphotextularia kreuzbergi* n.sp. (5, type).  $\times 45$ . FIGS. 7, 8—*Siphotextularia ihungia* n.sp. (7, type).  $\times 30$ . FIGS. 9, 10—*Siphotextularia subcylindrica* n.sp. (9, type).  $\times 45$ . FIGS. 11–13—*Eggerella ihungia* n.sp. (12, type; others from 5056).  $\times 45$ . FIGS. 14, 15—*Eggerella columna* n.sp. (15, type).  $\times 30$ . FIGS. 16, 17—*Dorothia elongata* n.sp. (16, type).  $\times 30$ . FIGS. 18–20—*Karrerulina bortonica* n.subgen. n.sp. (19, type).  $\times 45$ . FIGS. 21, 22, 25, 26—*Karrerulina aegra* n.subgen. n.sp. (26, type; 21, 22 from 5540).  $\times 45$ . FIGS. 23, 24—*Karrerulina clarentia* n.subgen. n.sp. (24, type).  $\times 45$ . FIGS. 27–29—*Laticarinina halophora* (Stache). (27 from 1279; 28, 29 from 5047).  $\times 30$ . FIGS. 30–34—*Parvicarinina altocamerata* (H.A. and E.) (31, 33, 34 from 5099, normal; 30, 32 from 3029, wide flange).  $\times 30$ .

To face page 460.





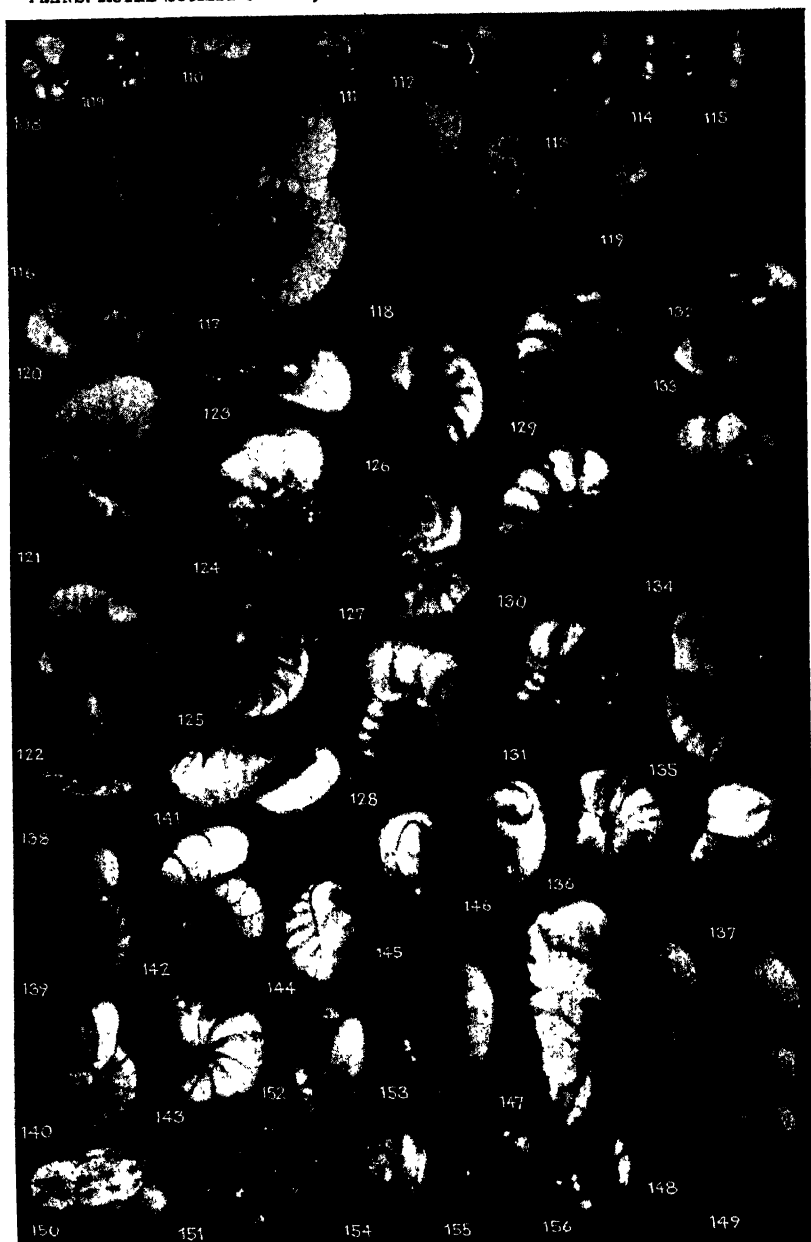
FIGS. 35-37—*Karreriella novosealandica* Cushman (5382, Upper Bortonian).  $\times 30$ .  
 FIGS. 38-42—*Karreriella cushmani* n.sp. (38, 39, 42 from G.S. 1240, Upper Ihungia;  
 40 from G.S. 1342, Tutamoe; 41 from 5105, Hutchinsonian; 39, type).  $\times 30$ .  
 FIGS. 43-46—*Karreriella cylindrica* n.sp. (43, 44 from 5557A, Cheviot "grey marl";  
 Taranakian; 45, 46 from 5207, Opoitian; 44, type).  $\times 30$ . FIG. 47—*Nodosaria*  
*subtetragona* n.sp. (type).  $\times 30$ . FIG. 48—*Nodosaria* (?) *multicostales* n.sp. (type).  
 $\times 30$ . FIG. 49—*Nodosaria sinuata* n.sp. (type).  $\times 30$ . FIGS. 50-52—*Gumbelina*  
*ototara* n.sp. (52, type).  $\times 45$ . FIGS. 53-55—*Gumbelina panikaua* n.sp. (53, type).  
 $\times 45$ . FIGS. 56-58—*Bolvetinoides darreent* n.sp. (57, type).  $\times 45$ . FIGS. 59-61—  
*Rectobolvetina hangaroana* n.sp. (59, type).  $\times 60$ . FIGS. 62-66—*Cassidinella cuneata*  
 n.sp. (62, 66 from 3187,  $\times 45$ ; 63-65 from 5273, All Day Bay,  $\times 30$ ; 66, type).  
 FIGS. 67-69—*Nuttallides tholus* n.sp. (67, type).  $\times 30$ .





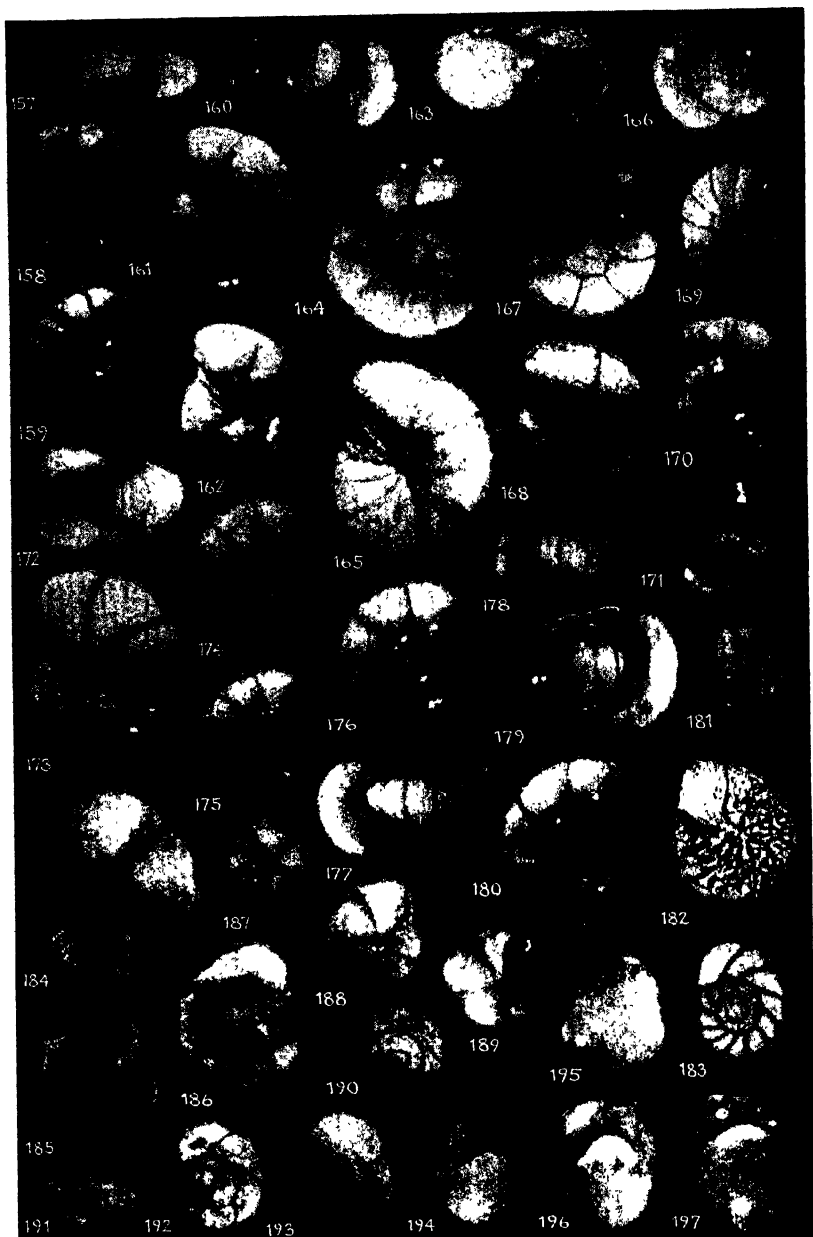
FIGS. 70, 71—*Bulimina niolaevis* n.sp. (70 from 3312,  $\times 45$ ; 71, type,  $\times 30$ ).  
 FIG. 72—*Bulimina mapihia* n.sp. (type).  $\times 90$ . FIGS. 73, 74—*Bulimina senta* n.sp.  
 (73, type).  $\times 45$ . FIGS. 75, 76—*Bulimina rakauaroane* n.sp. (75, type).  $\times 45$ .  
 FIGS. 77–81—*Bulimina forticosta* n.sp. (77–79 from 5359; 80, 81 from Waitangi No. 1  
 Well Core; 81, type).  $\times 30$ . FIGS. 82, 83—*Bulimina scobinata* n.sp. (82, type,  $\times 30$ ;  
 83 from 1005,  $\times 45$ ). FIGS. 84–88—*Bulimina brenneri* n.sp. (80, type,  $\times 45$ .  
 FIGS. 87, 88—*Bulimina pahiensis* n.sp. (87, type).  $\times 45$ . FIGS. 89–91—*Bulimina*  
*truncanella* n.sp. (91, type).  $\times 45$ . FIGS. 92–94—*Cancris amplius* n.sp. (92, type).  
 $\times 45$ . FIGS. 95–98—*Cancris brevior* n.sp. (96, type).  $\times 30$ . FIGS. 99–101—*Cancris*  
*compressus* n.sp. (99, type).  $\times 30$ . FIGS. 102–104—*Cancris mauricus* n.sp. (102,  
 type).  $\times 30$ . FIGS. 105–107—*Cancris lateralis* n.sp. (107, type).  $\times 45$ .





FIGS. 108-110—*Nonion tota* n.sp. (109, type).  $\times 45$ . FIGS. 111-115—*Anomalina aotea* n.sp. (112, type).  $\times 30$ . FIGS. 116-119—*Anomalina visenda* n.sp. (117, type).  $\times 30$ . FIGS. 120-122—*Anomalina vitrinoda* n.sp. (120, type).  $\times 45$ . FIGS. 123-127—*Anomalina senitensis* n.sp. (123, 124 from 5179B,  $\times 45$ ; 125 from 5601,  $\times 30$ ; 126, 127 from 3286,  $\times 30$ ; 124, type). FIGS. 128-131—*Anomalina miosuturalis* n.sp. (128, type).  $\times 45$ . FIGS. 132-137—*Anomalina eosuturalis* n.sp. (132, 133, 136, 137 from 5300; 134, 135 from 5068A; 134, type).  $\times 45$ . FIGS. 138-140—*Anomalina eoglabra* n.sp. (139, type).  $\times 45$ . FIGS. 141-143—*Anomalina macraglabra* n.sp. (142, type).  $\times 45$ . FIGS. 144, 146—*Nonionella magnalungua* n.sp. (146, type).  $\times 45$ . FIG. 147—*Gaudryina minuscula* n.sp. (5182, Cormack's, Oamaru, Kaikatoan).  $\times 45$ . FIGS. 148-149—*Amphicoryne prora* n.sp. (5273, All Day Bay; Awamoan).  $\times 45$ . FIGS. 150, 151—*Globigerina circumnodifer* n.sp. (151, type).  $\times 45$ . FIGS. 145, 152-156—*Nonionella zenitensis* n.sp. (152-156 from 5170A; 145 from 5273; 155, type).  $\times 45$ .





FIGS. 157-159—*Anomalina parvumbilica* n.sp. (158, type).  $\times 45$ . FIGS. 160-165—*Anomalina pinguilabra* n.sp. (160-162 from 5132; 163-165 from 5273; 164, type).  $\times 45$ . FIGS. 166-171—*Anomalina spherica* n.sp. (166, 169 from 30f. N. of Hen and Chickens; 167, 168, 170, 171 from G.S. 1155).  $\times 45$ . FIGS. 172-180—*Anomalina subnonionoides* n.sp. (172, 173 from 5273; 174, 175, 177, 178 from G.S. 475; 176, 179, 180 from 5132; 173, type).  $\times 45$ . FIGS. 181-183—*Gyroidina infrafosea* n.sp. (182, type).  $\times 30$ . FIGS. 184-186—*Pulvinulinella acutimarginata* n.sp. (184, type).  $\times 45$ . FIGS. 187-192—*Pulvinulinella creta* n.sp. (187, 190 from 5374; 188, 189, 191, 192 from 3250A; 189, type).  $\times 45$ . FIGS. 193-197—*Aluomorphina whangata* n.sp. (193, 194 from 5098; 195-197 from 3249; 194, type).  $\times 45$ .





Figs. 198-199—*Cibicides medietis* n.sp. (198, type). × 45. Fig. 200—*Cibicides*  
*capillus* n.sp. (type). × 30. Figs. 201-208—*Cibicides humphii* n.sp. (201, 202, 205  
from 8029; 203, 204, 206 from 4270; 202, type). × 80. Figs. 207-209—*Cibicides*  
*verrucosus* n.sp. (209, type). × 45. Figs. 210, 211—*Cibicides amoenus* n.sp. (210  
from 5276; 211, type). × 45. Figs. 212, 213—*Discorbis scopos* n.sp. (212, type).  
× 45. Figs. 214-216—*Discorbis turgidus* n.sp. (216, type). × 80. Figs. 217-221—  
*Discorbis appositus* n.sp. (219, type). × 30. Figs. 222, 223—*Discorbis jugosus* n.sp.  
(223, type). × 45; 224-225—*Sphaeroidinella disjuncta* n.sp. (224, 225 from  
G.S. 1342, × 45; 226-228 from 4270, × 30; 228, type).



less curved, umbilicus a little narrower and shallower; size, 0.45 mm. Type from 5601, Kaiata mudstone; also in Piripauan (3250A), Bortonian (5540), and Whaingaroan (5047).

**Anomalina parvumbilia** n.sp. (Plate 66, figs. 157-159.)

Compressed, periphery bluntly angled, bevelled each side, subequally convex above and below, ventrally involute with tiny umbilicus, dorsally with proloculum and 2 visible coils, narrower than in other species, not rapidly enlarging; about 12 chambers in last, sutures strongly curved, limbate, especially nearing spiral suture and umbilicus. Surface finely and densely punctate. Aperture with prominent lip running from umbilicus, curving round periphery and ending just above it, not running back along dorsal suture. Size, 0.5 mm.

Type from 5132, Clifden, upper Hutchinsonian. Common in Miocene. Not seen below true Hutchinsonian, though a related form occurs rarely down to Bortonian (5300) and even Piripauan (3250A); ranges up at least to Nukumaruan (5395).

Of the *Anomalinas* here described, those characteristic of the Pliocene are *spherica* and *parvumbilia* (both abundant); the only ones observed in the Taranakian are *parvumbilia* (common in upper part), *vitrinoda* (common in lower part, ? absent in upper), and occasionally *spherica*; while *miosuturalis*, *subnonionoides*, *pinguiglabra* and *macraglabra* do not seem to outlast the Awamoan.

Several of these species have been confused in the past with the European *rotula* d'Orb, but there are many distinct forms of this general type.

Genus *ROTALIA* Lamk., 1804.

In discussing this genus (*Trans. Roy. Soc. N.Z.*, vol. 68, pt. 4, p. 524, 1939) I considered *beccarii* and its allies *schroeteriana*, *conoides*, etc., as typical. But Mr. Parr has pointed out to me that *trochidiformis* Lk., the genotype, has a secondary series of chambers on the under side and that *Streblus* Fischer, 1817, should be used for the common Recent group. The type is *S. tortuosus* Fischer, a form of *beccarii*. Specimens of this Mediterranean species and the good figures of all growth stages given by Cushman (*CCL*, 4, 4, p. 104, pl. 15, 1928) differ from New Zealand specimens in being larger, flatter, and more ornate, the sutures heavily limbate and developing nodules when adult, the base very pustulose. True *beccarii* does not occur here, and the New Zealand form may be named:—

**Streblus aoteanus** n.sp.

Similar in general details to *Rosalina parkinsoniana* d'Orb., described from shore sands of Cuba, and figured from the Pleistocene of Maryland by Cushman (*CCL*, 6, 4, p. 100, pl. 13, fig. 14, 1930), but with much smaller umbilicus and plug, with narrower surrounding and sutural channels, the basal chambers much narrower, elongate, and more pointed. The total width of umbilicus is less than one-sixth of shell diameter, while in the West Indian form it is more than a quarter. Dorsally smooth, somewhat convex; 11 chambers per coil. Size, 0.55 mm.

Type from 5091, subfossil, Dunedin Harbour; dredged mud. Fossil throughout the Pliocene, but not common; probably absent below this.

A congeneric South Australian form has been figured from Hardwicke Bay shore sand as *Rotalia perlucida* H.-A. and E. by Parr (*Proc. Roy. Soc. Vict.*, vol. 42, pt. 1, N.S., p. 231, pl. 22, fig. 35, 1929). This has only 17 chambers per coil and is not at all like Heron-Allan and Earland's original figure which Cushman (*U.S. Nat. Mus. Bull.*, 104, pt. 8, p. 63, pl. 13, fig. 4, 1931) stated did not seem to represent a *Rotalia*. This Australian form is more like *tepida* Cush., but would be better described as new, as would also the Upper Pliocene Abbatoirs Bore form which Howchin and Parr (*Trans. Roy. Soc. of S.A.*, vol. 62, pt. 2, p. 303, 1938) recorded as *beccarii*; it has an enormous plug joined to the chamber ends and no surrounding channel at any stage. Forms quite close to *aoteanus* do, however, seem to occur in Tasmania and N.S.W. from the few specimens seen.

Mr Parr will be dealing with some of these Australian forms later; in a recent letter he has pointed out that the investigation of *R. trochidiformis* and the rejection of *Rotalia* for the *beccarii* group must be credited to Davies (*Trans. Roy. Soc. Edinburgh*, vol. 57, pt. 2, no. 13, pp. 401-428, Pls. 1-4, 1932), but that the selection of *Streblus* as the most suitable name for the latter is due to Dr Macfadyen.

**Gyroidina infrafossa** n.sp. (Plate 66, figs. 181-183.)

Plancoconvex, periphery angled but not sharp, gently rounded above, about 3 coils, 10 chambers in last, sutures almost straight, sloping back at 45°, flush, hidden by layer of translucent material becoming progressively thicker on early chambers; base overridden by heavy sculpture mostly obscuring sutures, numerous irregular pitted ridges and anastomosing rugae radiating from umbilicus, abruptly ceasing just before periphery; aperture a narrow slit running from umbilicus up to but not over periphery. Size, 0.77 mm.

Type from 5374; index of Piripauan. Not yet seen in South Island type Piripauan, but present throughout North Island Tapu-waeroa and Whangai. Probably related to the Velasco *Rotalia beccarii-formis* var. of White (*Journ. Pal.*, vol. 2, no. 4, p. 287, pl. 39, fig. 4, 1928), but with still heavier ornament.

**Nuttallides tholus** n.sp. (Plate 63, figs. 67-69.)

The representative in our Cretaceous of *N. micheliniana* (d'Orb.), but dome-shaped with faintly concave top instead of conical; 6-8 chambers per coil, basal sutures not sigmoid, umbilicus small and shallow, dorsal coils very narrow with very slanting radial sutures, periphery a thin jagged edge turned up as a tiny flange, aperture mostly along ventral contact of last chamber, but upper end turning outwards as in *Pulvinulinella*. Size, 0.7 mm.

Type from 3242, Mata S.D., basal Rakauaroa conglomerate; index of lower Rakauaroa (Piripauan).

**Pulvinulinella acutimarginata** n.sp. (Plate 66, figs. 184-186.)

Differs from *tenuimarginata* C., P., and C. (*Journ. Linn. Soc. Zool.*, vol. 38, p. 565, pl. 9, fig. 19, 1934) mainly in having a still

more acute periphery marked by a narrow thin flange instead of a more or less sharp angle; shell larger, compression slightly greater, and ventral meeting of chambers not depressed. Size, 0.65 mm.

Type from 5664, Saurian beds, Mid-Waipara Section; type Piripauan. Index of this and Whangai. *P. tenuimarginata* enters in Lower Bortonian (5540), and is more or less common to end of Miocene; last seen in Lower Opoitian (G.S. 1155, Hicks' Bay).

Another Cretaceous species is *Pulvinulinella creta* n.sp. (plate 66, figs. 187-192), with sub-angled periphery; a small less compressed shell, flattish on top, somewhat conic below, dorsally with about 3 visible coils, about 5 chambers in each, slightly bulging at margin to give a pentagonal outline (the other two species are circular); aperture more open, with blunt lips. Size, 0.35 mm. Type from 3250A, Whangai. Also in 5664 and Lower Rakaurua. Index of Piripauan.

*Cancris amplus* n.sp. (Plate 64, figs. 92-94.)

Large, smooth, shining, finely perforate, very inflated, chambers progressively more swollen, 6 in last coil above and below, flat above, flatly sloping below, periphery broadly rounded, sutures slightly limbate, later a little depressed, almost straight, deeply sunken on meeting umbilicus, round which blunt points of chambers protrude; last chamber balloon-like without keel; aperture reaching from periphery to penultimate chamber, almost hidden by lip, translucent patch large, circular. Size, 0.85 mm.

Type from 5273, Awamoan; index of true Hutchinsonian to Awamoan when common, but lasts to Opoitian (2057).

*Cancris brevior* n.sp. (Plate 64, figs. 95-98.)

Like *amplus* but relatively shorter, wider and more compressed; 5 chambers in last coil, more rapidly uncoiling and with last much less inflated; periphery on aperture side bluntly sub-angled, elsewhere rounded; points of chambers entering umbilicus forming pronounced ridges; aperture shorter, more widely open; translucent area still larger, more lateral. Size, 0.6 mm.

Type from 5630, Lower beds, Pakaurangi Point. Index of true Hutchinsonian.

*Cancris lateralis* n.sp. (Plate 64, figs. 105-107.)

Somewhat like *brevior* in shortness and width but with strong tendency to still greater lateral expansion; considerably smaller and still more compressed; periphery everywhere bluntly angular; dorsal chambers much more elongate and narrow, crescent shaped instead of sub-triangular, 9 in last coil. Ventrally 6 chambers visible, others obscured by heavy rugae overriding sutures. Aperture narrow, almost hidden by sinuous lip. Translucent area oblong, oval. Size, 0.6 mm.

Type from 5127, Ardgowan shell pit, Oamaru, Awamoan. Index of Duntroonian (Chatton) to Awamoan age.

*Cancris compressus* n.sp. (Plate 64, figs. 99-101.)

Same elongate shape as *amplus* but much compressed, periphery angular all round, margin of last chamber especially sharp; 7

chambers in last coil, dorsal sutures broadly curved, ventral ones deepening progressively posteriorly but not forming rugae or projecting points, umbilicus being covered by apertural pad-like lip. Size, 0.55 mm.

Type from 5179A, Hampden, Upper Bortonian. Index of Upper Bortonian to Whaingaroan (1281, 5231), but always rare. Of all the forms here described this is nearest to *brongniarti* (d'Orb.), figured by Cushman, 1935 (*U.S.G.S. Prof. Paper, No. 181*, pl. 20, fig. 1) as similarly rare in the Jackson Eocene; but the N.Z. shell unwinds more rapidly and has much more curved dorsal sutures.

***Cancris maoricus* n.sp.** (Plate 64, figs. 102-104.)

Combines some features of *amplus* and *compressus*; relatively more elongate and much larger than either, considerably inflated and with same rounded periphery as in *amplus* till last chamber, which has sharp edge of *compressus*; dorsal surface markedly convex (flatish in *amplus*), 7 chambers in last coil, intermediate in shape between *amplus* and *compressus*. Aperture much as in *amplus* with similar open umbilicus and deep grooves. Translucent area roughly semicircular, broader than long, a large tongue-like pad extending from this area over umbilicus (hardly present in *amplus*, smaller but more obscuring in *compressus*). Size, 1 mm.

Type from 42 fathoms off Chicken Island, Hauraki Gulf. Common, not known from Tertiary. The European *auriculus* F. and M. is smaller and angled all round.

***Cibicides mediocris* n.sp.** (Plate 67, figs. 198, 199.)

Compressed, planoconvex, edge fairly sharp. Dorsally flat or faintly convex, only one coil distinctly visible, central part obscure and a little raised, with 9-10 chambers, sutures at right angles to spiral suture and flush at first, then strongly curved and depressed on last 3-4 chambers, not limbate, surface regularly, densely and somewhat coarsely punctate; ventrally lightly convex, medially flattened, sutures curved into weak umbilicus. Smooth and shining, with fine dense punctae; aperture normal, continued back dorsally for about 3 chambers. Size, 0.8 mm.

Type from 5273, Awamoan. Common in middle and lower Miocene, beginning in Waitakian. *Cibicides perforatus* (Karrer) (*Novara Pal.*, vol. 1, p. 81, pl. 16, fig. 13, 1864) from the true Hutchinsonian of Orakei Bay is much thicker, bluntly conical below with a large plug-like boss covering up to half of ventral surface, with very obscure and mottled dorsal surface, spiral and radial sutures indistinct after a third of coil from aperture, about 12 obscure chambers little curved above or below. Topotypes have a bluntly angled edge, but this is due to wear; good specimens from other localities of Waitematan age show no perceptible distinction from the later described *Cibicides maculatus* (Stache) (*ibid.*, p. 278, pl. 24, fig. 28), from the Mid-Oligocene Whaingaroa beds, which I regard as a synonym. This species ranges down to the basal Kaiatan (5244, etc.), where it is common, but is not in the Tahuian or Bortonian; its upward limit seems to be Hutchinsonian.

The Lower Pliocene and Taranakian form differs from *mediocris* only in being not quite so flattened, more convex basally, still more sharply edged, and better defined dorsally, two coils with slightly limbate spiral and radial sutures being clearly visible, instead of an obscure central area with sutures definite for less than one coil; it may be called *Gibicides deliquatus* n.sp. (size, 0.9 mm.; type from 5408, near Nuhaka; Waitotaran silts). Upper Pliocene and Recent specimens are close but not quite the same.

Occurring with *mediocris* in the Lower Miocene is a related form, *Gibicides catillus* n.sp. (plate 67, fig. 200), still more compressed, with acute edge, faintly convex to concave on top without central swelling, little convex below, about 3 dorsal coils visible with 10 finely punctate chambers in last, early coils covered with translucent material, coils and chambers narrower, sutures much more curved, especially near outer edge, ventral sutures strongly curved medially, aperture weaker dorsally, running back for 3 chambers. Size, 0.8 mm.; type from 5699, basal Grey Marls, Weka Creek. This has been seen in Duntroonian (5636, 5692), "Blue Bottom" (5364, etc.), and rarely in Taranakian (3137).

***Gibicides ihungia* n.sp.** (Plate 67, figs. 201-206.)

Small, planoconvex, periphery fairly acute, dorsally flat or slightly concave, one coil visible, about 10 chambers; sutures slightly curved, directed back at  $45^{\circ}$ , heavily limbate but not much raised, centre entirely obscured by irregular mass of smooth shell substance, merging into limbation of spiral suture; non-limbate areas with moderate-sized perforations but no deep pits; ventral surface dome-shaped, slightly hollowed at centre, earlier chambers smooth with occasional small pits, last 4 or 5 with coarse distant punctae. Aperture normal, running back along suture for about 2 chambers. Umbilical plug thick, of darker substance. Size, 0.6 mm.

Type from 5846, Pourerere, Middle Ihungia. Enters in Duntroonian (5660, 5692), a few specimens in Lower Opoitian of Mangaruhe Stream, but rare at ends of range, common only in Hawke's Bay and Poverty Bay Ihungia. Related to *cicatricosa* Schw. but flat or concave on top, sides sloping inwards much more slowly below rather acute edge, more of base flattish, and especially much weaker ornament; Schwager's original figure shows very coarse pitting all over dorsal surface and most of base, and this is confirmed by Cushman's recent excellent figures of topotypes (*Trans. Pal. Soc. Japan*, vol. 46, p. 153, pl. 10, fig. 19, 1939). Specimens seen from the New Guinea Miocene (Upper Mena formation) are intermediate between the two species, with coarser punctae than *ihungia*.

***Gibicides verrucosus* n.sp.** (Plate 67, figs. 207-209.)

Dorsal surface flatly convex showing one coil (others obscured by papillae) with about 11 chambers, sutures slightly curved outwards, whole central portion covered with irregular coalescing papillae of moderate size, obscurely defined, rest of surface finely punctate; ventral surface lightly convex and smooth, with slightly curved sutures and translucent umbilical boss flush with surface. Size, 1.1 mm.

Type from 5678, base of Chalk Marl below Amuri Stone, Mid-Waipara; basal Kaiatan. Index of Kaiatan and Whaingaroan. This and *C. collinsi* are two of the most characteristic species of the Ototaran in all its facies. In the South Island they are almost always present, especially *verrucosus*, but have not been seen in the real Duntroonian or its equivalent the Weka Pass Stone. *C. collinsi* ranges down into Upper Bortonian in the South Island, and occasionally in the North (1014, Te Hua marl), but is usually replaced there by *C. tholus* Finlay. *C. verrucosus* is common in the Whaingaroan Weber formation, and seems to range in the North Island up into the Waitakian, occurring with *Cassidulina cuneata* in 5854 (Mangaotero S.D., pre-Ihungia mudstone).

Another papillose species is *Cibicides amoenus* n.sp. (plate 67, figs. 210, 211); much smaller, flatter, symmetrically convex with acute periphery bordered by narrow flange; 1 dorsal coil visible with 12 chambers, central papillae smaller, more numerous, distinct, hardly joined; chambers with conspicuous but fine punctae; ventral surface smooth, shining, with sinuous sutures; size, 0.6 mm.; type from G.S. 1240, Upper Ihungia. This is not common and seems confined to true Hutchinsonian. Specimens from the Upper Pliocene of New Guinea (Upper Ouba formation), however, seem inseparable.

***Cibicides collinsi* n.sp.**

Dorsal surface lightly convex, showing a little over 2 coils, with 8-9 chambers in last, sutures straight, inclined backwards at about 70°. Whole surface overlain with translucent shell substance, very thick centrally (through which early chambers show), penetrated by long, distant pores, absent over sutures. Ventral surface fairly convex, bluntly pointed at umbilicus, which is entirely filled with large translucent plug continued out into limbate sutures, chamber surface smooth, pores invisible at 36 magnification; aperture an arched opening on bluntly rounded periphery continued slightly back along dorsal suture. Size, 0.6 mm.

Type from 5635, Chalk Marl, lower part of Amuri limestone, Stoneyhurst S.D., Upper Bortonian. Ranges from here to Whaingaroan (5681, Mid-Waipara). Allied to *C. perlucida* Nuttall (*Journ. Pal.*, vol. 6, No. 1, p. 33, Pl. 8, f. 10-12, 1932), which has punctate base and angled edge.

***Discorbis scopos* n.sp. (Plate 67, figs. 212, 213.)**

Of the *bertheloti* type but much larger, with prominent proloculum forming a projecting bulb at dorsal centre, 6-7 chambers in last coil, number increasing on early whorls, a little inflated, with heavily limbate sutures except near periphery, which is marked by sharp limbate keel. Dorsally moderately convex, base lightly convex inside margin, excavated over the widely open umbilicus, which is filled with tongues projecting from base of chambers, hiding aperture, which barely reaches periphery in adults, turns over it (like *Cibicides*) in juveniles. Size, 1 mm.

Type from 5273, Awamoan, common at this horizon. In the Hutchinsonian (and Waitakian) is the related *Discorbis galerus* n.sp., differing only in smaller inconspicuous proloculum and especially

excavated base, which is concave all over (occasionally quite flat), last chamber more spreading and embracing, upper surface regularly convex, not interrupted by the less limbate sutures. Size, 0.75 mm. Type from 5730, Pakaurangi Point lower beds; true Hutchinsonian.

In the basal zone (Duntroonian) of the Waitakian nearly always occurs a special form of this, *Discorbis turgidus* n.sp. (plate 67, figs. 214–216), differing only in the very high dorsal surface, the chambers so swollen that height is about two-thirds width, base flat, shell thicker and more compact; size, 0.55 mm.; type from 5660, Waiparia *elliptica* greensands at base of limestone,  $\frac{1}{2}$  m. E. of Duntroon. It occurs up as far as Lower Hutchinsonian (5385, All Day Bay) in company with *galerus*, but has not been seen in true Hutchinsonian.

In the Bortonian a smaller relative, *Discorbis appositus* n.sp. (plate 67, figs. 217–221) is common; adults reach only two-thirds size of *scopos*, are especially much more compressed, the base flatly so; upper surface lightly rounded, limbate flange not far from medial in position; sutures heavily limbate, whorls a little swollen near umbilicus; size, 0.73 mm. Type from 5179B, Hampden, Upper Bortonian; also in Lower Bortonian (5540) and reaching Whaingaroan (1279).

In a few Bortonian faunas occurs *Discorbis jugosus* n.sp. (plate 67, figs. 222, 223) (type from 4266, Tangihanga, Poverty Bay, Upper Bortonian—also in 5102, 5776, Hawke's Bay), having 9–10 chambers in last coil with much thickened and raised sutures, larger than the chambers, especially swollen near wide umbilicus, merging into thick peripheral cord, top and bottom sub-equally flatly convex, aperture obscure, but apparently of this group, though chambers do not expand rapidly as in the other species; size, 0.9 mm. Seen only in Upper Bortonian of North Island; the Mexican Lower Tertiary *Cibicides cushmani* Nuttall (*Journ. Pal.*, vol. 4, no. 3, p. 291, Pl. 25, f. 3, 5, 6, 1930) is less symmetrical and has narrower chambers.

#### PABVICARININA n.gen. (Fam. Discorbidae).

Genotype: *Truncatulina tenuimargo* var. *alto-camerata* Heron-Allen and Earland.

This was described (*Terra Nova Exp.*, Zool., vol. 6, no. 2, p. 209, pl. 7, figs. 24–27, 1922) from 100 fathoms, 8 m. S. 14° W. of Big King Is. and noted to be well distributed. This is equally so for the Tertiary, and the species has a geological range back to Oligocene in company with the species usually called *Laticarinina pauperata*. It is not congeneric with either this species or with the real *tenuimargo*. When Brady described the latter (*Chall. Rep.*, vol. 9, p. 662, pl. 93, figs. 2, 3, 1884) he confused two very distinct forms; one from station 174A, Fiji (figs. 3a, b, c) and the other from West Coast of N.Z. The Indo-Pacific form (a *Cibicides*) has usually been regarded as typical; in case no rigid selection has yet been made, I now nominate this Fijian species (pl. 93, fig. 3) as *tenuimargo* s.str. On the strength of fig. 2, both species have been referred to under *Laticarinina*, but *pauperata*, though with similar chamber development and large flange, has an aperture just below edge of flange (on convex side), in a slight prolongation of chamber in direction of coiling.

*menardii* subvar. *pauperata* " Parker and Jones, 1865) must apparently be replaced. The year previously Stache had described from our Oligocene Whaingaroa beds two species as *Robulina halophora* and *corona-lunae* (*Voy. Novara*, Pal., vol. 2, pp. 248 and 250, pl. 23, figs. 28 and 29). In the numerous faunas from at and near the type locality now seen there are no Cristellarians remotely like his figures, but large *pauperata* forms are abundant and can be matched with his pictures in every way, though fig. 28b is idealised. Compare even the flange ornament shown by him with the Challenger figures of Brady (pl. 104, figs. 4, 5). Specific discrimination seems impossible, and this Mid-Eocene to Recent form should henceforth be referred to as *Laticarinina halophora* (Stache). For comparison with Stache's and Brady's figures and Recent specimens, Whaingaroan specimens are here figured—a practical topotype from 1279 (plate 62, fig. 27), and Oxford Chalk examples from 5047 (plate 62, figs. 28, 29).

The aperture of *altocamerata*, however, is quite different. It is also a tubular extension of the chamber, not of the lower front face, however, but of the base, and coiled backwards to point in towards umbilicus at right angles to coiling (quite well shown in Brady's fig. 2a). Also, similar apertural tube openings are visible for several previous chambers, while *Laticarinina* has all chambers surrounded by translucent shell substance and opening only invisibly into each other. The normal form is here illustrated from the basal Waitakian of Weka Creek (5699; pl. 62, figs. 31, 33, 34), and one with an unusually wide carina from the Hutchinsonian of Whangara (3029; pl. 62, figs. 30, 32).

Another species of *Parvicarinina* seems to be *Discorbis plano-concava* (Parr) first described as a Recent variety of *Planulina biconcava* P. and J. (*Proc. Roy. Soc. Vic.*, vol. 42, pt. 1, p. 232, pl. 22, fig. 34, 1929), and later (*Journ. Linn. Soc. Zool.*, vol. 38, p. 561, pl. 11, fig. 40, 1934) referred to *Discorbis* by reason of an aperture which seems like *Parvicarinina*; it occurs in 60 fathoms off Poor Knights Is. but is not yet known as a fossil.

A rare and much more restricted species is *Parvicarinina deflata* n.sp., differing from *altocamerata* only in the compressed pinched-in chambers, the posterior sides concave; size, 0.4 mm. It has been seen in the Hutchinsonian (type from 5274, Marsden "Blue Bottom") and Taranakian (5703). Neither *Laticarinina* nor *Parvicarinina* occurs in our Cretaceous, though ubiquitous almost after; the former beginning in Upper Bortonian (3254), the latter not yet seen before Kaiatan (5601, 5182).

#### **Allomorphina whangaia** n.sp. (Plate 66, figs. 193-197.)

Small, inflated, sub-trigonal; spire very depressed, little raised above surface of last whorl, 3 closely knit chambers per coil. Somewhat bulbous, but base flattened, not globular as in *trochoides*; aperture at junction of chambers about half width of shell, hidden by thin sinuous lip projecting from last chamber. Size, 0.4 mm.

Type from 5698; index of Whangai and type Piripauan (5664, 5666, 5301, 3249, etc.). This has the depressed spire of *A. minuta* Cush. (*CCL*, 12, 4, p. 72, pl. 13, fig. 3, 1936), but is less compressed and has differently shaped chambers.

**Globigerina circumnodifer** n.sp. (Plate 65, figs. 150, 151.)

Large, loosely coiled,  $4\frac{1}{2}$  chambers per coil, about 2 coils visible dorsally, ventrally nearly involute; spire flatly depressed, second coil more descending, chambers sub-globular, smooth, shining above and below but with faint peripheral sulcus margined by low nodules increasing in extent posteriorly to cover most of early chambers; umbilicus widely open, about one-third of shell diameter, aperture opening laterally into it, apertures of all ventral chambers probably visible if matrix absent. Size, 0.47 mm.

Type from 5698; Piripauan index. Evidently a close relative of the abundant Navarro *G. rugosa* Plummer (*Univ. Texas Bull.*, no. 2644, p. 38, pl. 2, fig. 10, 1926), which has 5 chambers per coil and more ornament of a different character. It is a moot point whether these are not *Globotruncana*, as they differ only in the absence of keels and feebler sculpture. The hard marl overlying the Waipawa black shale at Tanumi Bridge (5860) contains an abundance of *Gumbelina panikauia*, *Bolivinoidea dorreeni* and *G. circumnodifer*; also a few examples of a true *Globotruncana* differing from the latter mainly in keeling and compression.

**Sphaeroidinella disjuncta** n.sp. (Plate 67, figs. 224-228.)

Rather small, 3 to 4 chambers in ventral view, the fourth usually small, outline roughly triangular. Resembles *Globigerina triloba*, but much more coarsely pitted, early chambers especially having numerous pustules; sutures deep, heavily channelled near umbilicus; aperture small, rounded, forming with umbilicus a deep cavity. A frequent tendency for last chamber to be smaller than others and somewhat jutting. Size, 0.58 mm.

Type from 4270, Upper Ihungia. Continues from here throughout Taranakian (e.g. 3114, Upper Poha). In many respects half-way between *Globigerina* and *Sphaeroidinella*, lacking the polish, pore appearance and compactness of *dehiscens*, but less like *Globigerina* in chamber attachment and deeply cleft sutures. In a sample from the Miocene Upper Mena series of New Guinea a very closely related species occurred together with the true *S. dehiscens*, both abundant, but only the latter was found in samples from the overlying Lower and Upper Ouba series (mostly Pliocene). True *dehiscens* occurs in New Zealand at least as low as Urenuiian (5185, 5018).

## LOCALITIES REFERRED TO MORE THAN ONCE IN TEXT OR PLATES.

1005—Taiporutu Stream, Mahia Peninsula.

1279—Kariori S.D.; Whaingaroa clays,  $1\frac{1}{2}$  m. S.E. of Raglan, below basalt.

3029—Beach S. of Whangara, sandy marl between two massive marls.

3249—Waipiro S.D., calcareous sandstone bands in marls.

3250A—Waipiro S.D., mouth of Tuparoa Stream, marls in siliceous shale.

3270—Mangaoporo S.D., upper Mangaoporo Stream, basal Rakauroa.

3286—Turanganui S.D., Pouawa Dome, sandy marl.

3312—Hobson's Bay, Auckland, Waitemata beds (= Orakei Bay).

4270—Waikohu S.D., Tangihanga.

5018—Hangaroa Stream, type Poha Section, 400 ft. below top.

- 5047—Oxford Chalk, N. Canterbury.  
 5056—Takaka, Terakohe marl quarry, above bryozoan bed.  
 5105—Citrini's Area, near Kumara.  
 5132—Waiau River, Clifden, Southland; band 5, first marl outcrop above limestone.  
 5179A—Hampden beach, 1 m. N. of Kakaho Creek.  
 5179B—Hampden beach, 1½ m. N. of Kakaho Creek.  
 5182—Jackson's paddock, Oamaru, 1 m. S.W. of Cormack's Station, lower part of limestone.  
 5207—Eketahuna marl, roadside, first exposure S. of town.  
 5273—All Day Bay marl, Kakanui beach, 60 chs. at 153° from Trig V.  
 5276—Marsden "Blue Bottom," 6 m. S. of Greymouth, marl.  
 5300—Moeraki S.D., soft white marl at S. end of beach (McKay's marly clay).  
 5338—Mangaotero S.D., 175 ch. at 74° from Trig U.  
 5374—Mangaotero S.D., 148 ch. at 61° from Trig U.  
 5382—Porangahau S.D., 210 ch. at 84° from Trig U.  
 5540—Hampden beach, 22 ch. at 162° from Trig H, Lower Bortonian marl, just above glauconite.  
 5557A—Cheviot S.D., Kaikoura; marl 30 ch. S.W. of Trig sub Y.  
 5561—Cheviot S.D., Caroline Creek, 70 ch. E.N.E. from Trig sub B.  
 5601—Kaiata marl, lower part.  
 5698—Panikau Dome, Whangara, siliceous marl.  
 G.S. 475—Mount Harris, Waihao River, marly sandstone.  
 G.S. 1155—Hicks Bay, sandstone with *Cucullaea*.  
 G.S. 1240—Ihungia marl, Island Creek, Tutamoe S.D.  
 G.S. 1342—Waikura Stream, Putatahi S.D., basal Tutamoe.

## LIST OF NEW NAMES PROPOSED.

(For age equivalents see Finlay, 1939, *Trans. Roy. Soc. N.Z.*, vol. 68, pt. 4, p. 531.

## GENERIC.

- Conotrochammina* n.gen. (Fam. Ammodiscidae). Genotype: *C. whangaia* n.sp. (Uppermost Cretaceous).  
*Karrerulina* n.subgen. (Fam. Valvulinidae). Genotype: *Gaudryina apicularis* Cushman. (Turonian or earlier—Recent).  
*Parvicarinina* n.gen. (Fam. Discorbidae). Genotype: *Truncatulina tenuimargo* var. *altocamerata* Herron-Allen and Earland (Lower Oligocene—Recent).

## SPECIFIC.

- Conotrochammina whangaia* n.sp. (Campanian, perhaps to Danian).  
*Cyclammina grangei* n.sp. (Upper Cretaceous to Eocene).  
*Siphotextularia kreuzbergi* n.sp. (Lower to Middle Miocene).  
*Siphotextularia ihungia* n.sp. (Lower Miocene).  
*Siphotextularia subcylindrica* n.sp. (Upper Miocene).  
*Gaudryina minuscula* n.sp. (Lower Oligocene, Lower Miocene?).  
*Eggerella columna* n.sp. (Uppermost Cretaceous).  
*Eggerella ihungia* n.sp. (Lower Miocene).  
*Dorothia elongata* n.sp. (Santonian).  
*Karrerulina bertonica* n.sp. (Mid-Eocene to Oligocene).

- Karrerulina aegra* n.sp. (Danian to Lower Mid-Eocene).  
*Karrerulina clarentia* n.sp. (Turonian).  
*Karreruliella cushmani* n.sp. (Upper Oligocene to Middle Miocene).  
*Karreruliella cylindrica* n.sp. (Upper Miocene to Lower Pliocene).  
*Nodosaria subtetragona* n.sp. (Lower to Upper Miocene).  
*Nodosaria sinalata* n.sp. (Upper Miocene to Lower Pliocene).  
*Nodosaria* (?) *multicostales* n.sp. (Lower Pliocene).  
*Amphicoryne prora* n.sp. (Mid-Oligocene to Upper Miocene).  
*Gumbelina panikauia* n.sp. (Santonian).  
*Gumbelina ototara* n.sp. (Oligocene).  
*Bolivinoides dorreeni* n.sp. (Santonian).  
*Rectobolivina hangaroana* n.sp. (Uppermost Miocene).  
*Bulimina miolaevia* n.sp. (Lower Miocene).  
*Bulimina mapiria* n.sp. (Uppermost Miocene).  
*Bulimina rakauaroana* n.sp. (Santonian).  
*Bulimina senta* n.sp. (Lower to Upper Miocene).  
*Bulimina truncanella* n.sp. (Mid-Eocene to Upper Miocene).  
*Bulimina bremneri* n.sp. (Lower to Middle Miocene).  
*Bulimina forticosta* n.sp. (Upper Mid-Eocene to Mid-Oligocene).  
*Bulimina pahiensis* n.sp. (Upper Mid-Eocene).  
*Bulimina scobinata* n.sp. (Mid to Upper Oligocene).  
*Cassidulina cuneata* n.sp. (? Upper Oligocene, Lower to Upper Miocene).  
*Nonion iota* n.sp. (Mid-Eocene to Lower Oligocene).  
*Nonionella magnalingua* n.sp. (Upper Oligocene to Lower Pliocene).  
*Nonionella zenitens* n.sp. (Eocene to Middle Miocene).  
*Nonionella satiata* n.sp. (Middle Miocene).  
*Nonionella tanumia* n.sp. (Santonian).  
*Anomalina visenda* n.sp. (Mid-Eocene).  
*Anomalina aotea* n.sp. (Upper Cretaceous to Mid-Oligocene, perhaps later).  
*Anomalina vitrinoda* n.sp. (Mid-Oligocene to Upper Miocene).  
*Anomalina semiteres* n.sp. (Mid-Eocene to Lower Oligocene).  
*Anomalina miosuturalis* n.sp. (Upper Oligocene to Mid-Miocene).  
*Anomalina eosuturalis* n.sp. (Mid-Eocene to Mid-Oligocene).  
*Anomalina subnonionoides* n.sp. (Upper Oligocene to Mid-Miocene).  
*Anomalina spherica* n.sp. (Upper Miocene to Recent).  
*Anomalina pinguiolabra* n.sp. (Upper Oligocene to Mid-Miocene).  
*Anomalina macraglabra* n.sp. (Upper Oligocene to Middle Miocene).  
*Anomalina eoglabra* n.sp. (Campanian to Mid-Oligocene).  
*Anomalina parvumbilica* n.sp. (Lower Miocene to Middle Pliocene).  
*Streblus aoteanus* n.sp. (Lower Pliocene to Recent).  
*Gyroidina infra fossa* n.sp. (Santonian to Campanian).  
*Nuttallides tholus* n.sp. (Santonian).  
*Pulvinulinella acutimarginata* n.sp. (Santonian to Campanian).  
*Pulvinulinella creta* n.sp. (Santonian to Campanian).

- Cancris amplus* n.sp. (Lower Miocene to Lowest Pliocene).  
*Cancris brevior* n.sp. (Lower Miocene).  
*Cancris lateralis* n.sp. (Upper Oligocene to Middle Miocene).  
*Cancris compressus* n.sp. (Upper Mid-Eocene to Middle Oligocene).  
*Cancris maoricus* n.sp. (Recent).  
*Cibicides mediocris* n.sp. (Upper Oligocene to Middle Miocene).  
*Cibicides deliquatus* n.sp. (Upper Miocene to Lower Pliocene).  
*Cibicides catillus* n.sp. (Upper Oligocene to Upper Miocene).  
*Cibicides ihungia* n.sp. (Upper Oligocene to Lowest Pliocene).  
*Cibicides verrucosus* n.sp. (Lower to Upper Oligocene, Waitakian?).  
*Cibicides amoenus* n.sp. (Lower Miocene).  
*Cibicides collinsi* n.sp. (Upper Mid-Eocene to Mid-Oligocene).  
*Discorbis scopos* n.sp. (Middle Miocene).  
*Discorbis galerus* n.sp. (Upper Oligocene to Lower Miocene).  
*Discorbis turgidus* n.sp. (Upper Oligocene).  
*Discorbis appositus* n.sp. (Eocene to Middle Oligocene).  
*Discorbis jugosus* n.sp. (Upper Mid-Eocene).  
*Parvicarinina deflata* n.sp. (Lower to Upper Miocene).  
*Allomorphina whangaiia* n.sp. (Santonian to Campanian).  
*Globigerina circumnodifer* n.sp. (Santonian).  
*Sphaeroidinella disjuncta* n.sp. (Lower to Upper Miocene).

## The Carabidae (Coleoptera) of New Zealand.

### Part 1. PTEROSTICHINI

By EVERARD B. BRITTON, M.Sc., F.R.E.S.,

Department of Entomology, British Museum (Natural History).

Communicated by G. V. HUDSON.

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THE object of this paper is to present a revision of the Pterostichini of New Zealand. The Carabidae of the world are grouped into about fifty tribes, of which only fourteen are at present known to have representatives in New Zealand. I hope to be able to follow the present work with others on the remaining tribes.

I was led to undertake this revision by the fact that the types of the greater part of the described species of the New Zealand Carabidae are in the British Museum collections. The majority of the species were described by Major T. Broun, whose collection came to the British Museum as a bequest, in 1922. White and Sharp described many other species, the types of which are also available to me. The types of the species described by Dejean, Bates and Chaudoir are in the collections of Monsieur René Oberthür, and in order to study these I made a special visit to Rennes. I wish to take this opportunity of expressing my gratitude to Monsieur Oberthür for his hospitality and the great kindness shown to me during my visit.

I have now seen the types of all but six of the species referred to in this paper.

The most recent list (G. V. Hudson, *New Zealand Beetles and their Larvae*, 1934) includes about 160 species of Pterostichini, but the synonymy established in this paper reduces the number to 61 species.

The greater part of the synonymy has arisen, in the first place, because Broun was in many cases unable to identify the species described by those authors working in Europe. Secondly, Broun made no attempt to revise the many species of Carabidae described by himself, with the result that he not infrequently redescribed his own species under new names. In the present revision, the synonymy introduced has, in the great majority of cases, been verified by comparison of the male genitalia, which exhibit the most striking specific characters. Examination of the male genitalia of a series of individuals of the same species reveals a small range of individual variation which is, however, negligible in comparison with the differences between the genitalia of even closely allied species. It follows that the genitalia provide a reliable means of verifying synonymy and identification.

The male genitalia are perhaps most easily removed from dry pinned specimens by breaking the abdomen off by downward pressure

at its apex. The abdomen is then placed in boiling water for a short time, until the tissues are softened. An opening is made between the soft tergites of the upper side with a pair of needles, and the aedeagus removed through this. The aedeagus is then cleaned and mounted on a card attached to the pin, while the abdomen is gummed back in its place.

In species where a male has been available for dissection, an outline drawing of the male genitalia is given. In each figure, the upper drawing represents the aedeagus and paramere viewed from the side, while the lower drawing shows the apex of the aedeagus seen from above, to show its shape and degree of expansion. An outline drawing of the pronotum is also given for most species, for in my opinion an accurate figure is of more value than any description, however lengthy. Of all the external characters, the pronotum shows the most obvious specific differences, so that the figures should be of use in checking determinations. Four drawings of the whole insects are included to show the general appearance of the New Zealand *Pterostichini*.

For the convenience of those interested in the fauna, but who have no special knowledge of the Carabidae, I give a key to the fourteen tribes which are known to occur.

The biogeographical relations of the fauna are not dealt with here, as such facts can be expected to emerge only from monographs on complete systematic units, covering the whole range of distribution. Of the nine genera which I have recognised, seven are indigenous, while the other two, *Rhytisternus* and *Laemostenus*, each represented by only one species, have been introduced in recent times.

My best thanks are due to Mr. G. V. Hudson, who has helped me with the publication of this paper, and by his very generous gifts of insects to the British Museum. I am also indebted to Mr. C. E. Brookes, Dr. R. Jeannel and Dr. S. L. Straneo for sending me valuable material for examination. Lastly, I must thank Mr. G. E. Bryant, Mr. J. Balfour-Browne, Dr. F. van Emden, and Mr. J. F. Perkins for their opinions on various points in connection with the work.

#### KEY TO THE TRIBES OF CARABIDAE OCCURRING IN NEW ZEALAND.

- 1 Middle coxae not completely enclosed by the sterna;  
mesepimera reaching the coxal cavities between the  
mesepisternum and the metasternum.... (Carabinae) 2
- Middle coxae completely enclosed by the sterna; mese-  
    pimera not reaching the coxal cavities.. (Harpalinae) 4
- 2 (1) Clypeus without a seta at each anterior angle. . . . . Pamborini
- Clypeus with a seta at each anterior angle. . . . . 3
- 3 (2) Body not pedunculate; a seta in the outer hollow  
    (scrobe) of the mandible. . . . . Migadopini
- Body not pedunculate; without a seta in the scrobe of  
    the mandible. . . . . Scaritini
- 4 (1) With a seta in the outer hollow side (the scrobe) of the  
    mandible; or with a tuft of two or more setae arising  
    from the posterior supraorbital puncture. . . . . 5
- Without a seta in the scrobe of the mandible, and never  
    with more than one seta arising from the posterior  
    supraorbital puncture. . . . . 9

- 5 (4) Body pedunculate, prothorax connected with the rest of the body by a prolongation of the mesothorax bearing the scutellum; only one (the posterior) supraorbital puncture present on each side, this bearing two or more setae; mandible with or without a seta in the scrobe; large, usually much more than 10 mm. in length. . . . . **Broschini**
- Body not pedunculate; head with two supraorbital punctures, each bearing only one seta; mandible always with a seta in the scrobe; small, always less than 10 mm. in length. . . . . 6
- 6 (5) Terminal segments of the palpi very small and sharp-pointed (subulate). . . . . **Bembidiini**
- Terminal segments of the palpi not differing markedly in size from the penultimate segments. . . . . 7
- 7 (6) Elytra having an inner fold which visibly interrupts the margin in the emargination near the apex; frontal furrows of the head not extending back beyond the posterior margin of the eyes. . . . . 8
- Elytra with or without an inner fold, but never with it visible at the margin near the apex; frontal furrows of the head extending right around the eyes. . . . . **Trechini**
- 8 (7) Maxillary palpi with the penultimate segments hairy; tarsi hairy above; usually with a short carina near the basal angles of the pronotum; front tarsi in the male with two basal segments assymmetrically expanded, with a tooth on the anterior edge of each. . . . . **Merizodini**
- Maxillary palpi with the penultimate segments bare; tarsi bare above; pronotum without a carina near the basal angles; front tarsi in the male with three basal segments slightly expanded and symmetrical. . . . . **Nomiini**
- 9 (4) Mandibles short and thick, truncate or emarginate at the apex; clypeus more or less emarginate, often assymetrical, generally exposing the basal membrane of labrum. . . . . **Licinini**
- Mandibles entire and moderately sharp at the apex, basal membrane of the labrum not exposed. . . . . 10
- 10 (9) Head with one supraorbital setiferous puncture on each side; no setiferous puncture at the posterior angle of the pronotum on each side; the four basal segments of the anterior tarsus expanded in the male. . . . . **Harpalini**
- Head with two setiferous punctures on each side, very rarely without a setiferous puncture at the posterior angles of the pronotum; three basal segments of the anterior tarsus expanded in the male. . . . . 11
- 11 (10) The apices of the elytra rounded off together in a single curve; not truncate; the terminal segment of the abdomen normally covered. . . . . 12
- The elytra transversely, or more or less obliquely truncate at their apices; the terminal segment of the abdomen always visible. . . . . 13
- 12 (10) Mentum with a bifid tooth; elytra with an inner fold visibly interrupting the margin each side in an emargination near the apex. . . . . **Pterostichini**
- Mentum with a simple tooth; inner fold of the elytra not visible in the emargination near the apex. . . . . **Anchomenini**
- 13 (11) The mentum attached at the base to a projecting submentum; head not sharply constricted behind the eyes; pronotum cordiform; mandible with outer hollow. . . . . **Lebiini**
- The mentum attached at the base to the submentum which does not project; head very sharply constricted behind to a narrow neck; pronotum more or less pentagonal; mandibles with no outer hollow. . . . . **Pentagoniini**

No species of the Australian tribe *Pamborini* has yet been described from New Zealand, but amongst the Carabidae which were kindly sent to me by Mr. C. E. Brookes was a single imperfect specimen of a new genus and species of this tribe, taken in 1933 at Waimatenui, Kaikohe, in North Auckland, on an isolated mountain. The specimen is in the collection of Mr. E. Fairburn.

I anticipate that this species will be described when more material has been obtained, and for this reason I have included the tribe in the key.

The characters which distinguish the Pterostichini are as follows: head with two setae above each eye; mentum with a bifid tooth; the paraglossae extending beyond the glossa, which has two setae at the apex (fig. 78); the penultimate segments of the labial palps bearing two setae on the inner side; terminal segments of the palps ovoid, truncate at their apices; antennae with the first three and part of the fourth segments bare, hairy beyond; the sides of the elytra emarginate towards their apices with an internal fold appearing in the emargination interrupting the margin; the tibiae of the front legs strongly dilated apically; the three basal segments of the tarsi of the front legs in the male symmetrically expanded and clothed beneath with two rows of lamellae.

In his work on the Carabidae of Tasmania, Sloane (*Proc. Linn. Soc. N.S. Wales*, 1920, XIV, p. 152), includes the Nomiini in the Pterostichini. The importance of the mandibular seta has, however, been stressed by van Emden (*Ent. Blätt.*, 1936, p. 41), who has shown a correlated character in the presence of setae on the parameres of the male genitalia. These genera with a scrobal seta should therefore be excluded from the Pterostichini and transferred to the Nomiini.

#### GENERA AND SPECIES TO BE EXCLUDED.

The following genera and species have been described from New Zealand, but for various reasons are excluded from the present work.

*Prosopogmus* Chaudoir, 1865, *Bull. Soc. Nat. Mosc.*, XXXVIII, iii, p. 92.

Described on the species *P. impressifrons* Chaudoir; locality "Nouvelle Zélande." This species, the type of which I have examined, occurs in Australia, as do other species of the genus. I have seen no examples of the genus from New Zealand, and the species has certainly not been redescribed under any other name. Doubt is therefore thrown on the original record and I have omitted the species from the New Zealand list.

*Rhabdotus reflexus* Chaudoir, 1865, *Bull. Soc. Nat. Mosc.*, XXXVIII, iii, p. 94.

The original locality of this species was given as New Zealand. The type is identical with examples from Tasmania. As there are no other New Zealand records of the species, the original record may be regarded as an error, as was suggested by Bates (*Ann. Mag. Nat. Hist.*, 1874, LXXV, p. 246).

**Molopsida polita** White, 1846, in Richardson and Gray, *Voy. Erebus and Terror*, Ins., p. 6; Broun, 1880, *Man. New Zeal. Col.*, I, p. 43.

This species has always been considered to be a Pterostichine, but I find that the type is identical with that of *Tarastethus laevicollis* Broun (Nomiini). *Tarastethus* Sharp, 1883 (*Ent. Mo. Mag.*, XX, p. 23) therefore becomes a synonym of *Molopsida* White, 1846.

*Molopsida polita* White, 1846 = *Tarastethus laevicollis* Broun, 1903, Sharp, 1883 (n.syn.).

**Selenochilus piceus** (Blanchard, 1853).

The excellent description of this genus and species by Chaudoir (*Bull. Soc. Nat. Mosc.*, 1878, LIII, ii, p. 18) leaves no doubt that it is synonymous with *Sympiestus syntheticus* Sharp, 1886. It must be referred to the tribe Nomiini.

*Selenochilus piceus* (Blanchard, 1853) Chaudoir, 1878 = *Sympiestus syntheticus* Sharp, 1886 (n.syn.).

**Drimostoma antarctica** Castelnau, 1867, *Notes on Australian Coleoptera*, p. 113; *Trans. R. Soc. Vict.*, VIII, 1868, p. 199; Bates, 1874, *Ann. Mag. Nat. Hist.* (4), XIII, p. 242; Broun, 1880, *Man. New Zeal. Col.*, I, p. 30; Sloane, 1898, *Proc. Linn. Soc. N.S. Wales*, XXIII, p. 472.

According to Bates, Chaudoir suspected this species to be an *Abacetus* or *Drimostoma*, having a deep linear impression on each side of the base of the pronotum. Sloane, however, considered it to be a species of *Tropidopterus*.

Prof. de Beaux assures me that the types of this and the following species are not in the Genoa Museum and suggests that they will probably be found in the Howitt Collection, which is in the National Museum, Melbourne.

**Drimostoma striato-punctata** Castelnau, 1867, *Notes on Australian Coleoptera*, p. 113; *Trans. R. Soc. Vict.*, VII, p. 199; Sloane, 1898, *Proc. Linn. Soc. N.S. Wales*, XXIII, p. 471.

This species was synonymised with *Mecyclothorax insularis* (Metchulsky, 1864) by Bates (1874, *Ann. Mag. Nat. Hist.* (4), XIII, p. 242), although Sloane considered this a mistake. Judging from the description, I am content to recognise the synonymy.

**Cerabilia** Castelnau, 1867, *Notes on Australian Coleoptera*, p. 116; *Trans. R. Soc. Vict.*, VIII, 1868, p. 202; Broun, *Man. New Zeal. Col.*, I, 1880, p. 44.

Through the kindness of Dr. S. L. Straneo, of Parma, I have been able to examine a specimen from the Genoa Museum, which I believe to be the type of *Cerabilia maori* Castelnau. It bears the label "N.Z. Dunedin," in the handwriting of Castelnau, the exact locality given in the description. It agrees perfectly with the description, except that there is a tooth on the mentum. The types of the Australian species described in the same work are in the Genoa Museum and have been studied by Dr. Straneo. It is therefore to be expected that the type of *Cerabilia maori* would be found in the same place, but search has failed to reveal a specimen bearing a determination label. The specimen which I have examined must certainly occupy a distinct

genus, and the description applies to no other New Zealand carabid known to me. In view of these facts I accept the example as the type of *Cerabilia maori*. The species was described in the Pterostichini, but I find that it must be transferred to the Anchomenini, as the inner fold of the elytra does not appear in the apical emargination and interrupt the margin, while the tooth of the mentum is simple.

Broun described two species in this genus, but examination of the types shows that *C. punctigera* Broun is synonymous with *Holcaspis sternalis* Broun, while *C. ruficornis* Broun is, in reality, a species of *Selenochilus* (Tribe Nomiini).

**Alogus monachicus** Motschulsky, 1865, *Bull. Soc. Nat. Mosc.*, XXXVIII, iv, p. 245; Broun, *Man. New Zeal. Col.*, I., 1880, p. 43.

From the description this species must belong to the Pterostichini, and probably to *Holcaspis*, but it is impossible to determine it with certainty.

**Holcaspis edax** Chaudoir, 1878, *Bull. Soc. Nat. Mosc.*, LIII, ii, p. 69.

The species cannot be identified from the description. I therefore omit it until such time as it can be accurately identified.

**Holcaspis pantomelas** (Blanchard, 1853) *Voyage au Pôle Sud*, Zool., IV, p. 27, pl. 2, f. 6 (*Argutor*); Tschitscherin, 1901, *Rev. Russe d'Ent.*, p. 47.

**Omasus sylvaticus** Blanchard, 1853, *Voyage au Pôle Sud*, Zool., IV, p. 29, pl. 2, f. 5; Chaudoir, 1865, *Bull. Soc. Nat. Mosc.*, XXXVIII, iii, p. 102; Broun, 1880, *Man. New Zeal. Col.*, I., p. 38.

Localities: Auckland Islands and Akaroa.

The types are lost and it is impossible to identify the species from the descriptions or figures. The length is given as 8-9 mm. It is highly probable that the species has been redescribed under another name by one of the later authors. I have, nevertheless, seen no examples of any species of *Holcaspis* less than 10 mm. in length, so that it seems probable that it is not a species of that genus.

#### DISTRIBUTION.

With regard to the distribution of the species in New Zealand little can be said on the small amount of available material, but it appears that the majority have a comparatively restricted range. It may be observed that while 40 species are found in the South Island, only 14 occur in the North Island, and 3 species are found on both sides of the Cook Strait. It is certain that a more detailed knowledge of the distribution of the species of Carabidae in New Zealand would be of exceptional interest and would throw light on the evolution of endemic species. This is, however, a work which entomologists resident in the country can best undertake. In this paper I include only the localities of those examples which I have seen and identified. The number of examples examined is given for each species.

All figures of pronotum and aedeagus, respectively, are made to the same scale.

## KEY TO THE GENERA OF PTEROSTICHINI OCCURRING IN NEW ZEALAND.

- 1 With a series of setiferous punctures on the 7th elytral interval. . . . . *Megadromus*  
 With no setiferous punctures on the 7th elytral interval. . . . . 2
- 2 (1) Basal segment of the antennae flattened or hollowed dorsally; inner side of the posterior tibiae in ♂ prolonged at apex. . . . . *Zeopoeilus*  
 Basal segment of the antennae rounded; posterior tibiae in ♂ without apical prolongation. . . . . 3
- 3 (2) Dorsal surface of all tarsal segments longitudinally grooved. . . . . *Aulacopodus* gen.n.  
 Dorsal surface of all tarsal segments smooth. . . . . 4
- 4 (3) Hind wings absent; elytra soldered together along the suture. . . . . 5  
 Hind wings present; elytra free, not soldered at suture. . . . . 7
- 5 (4) Mentum with a deep pit on each side towards the base (see fig. 78); 3rd elytral interval often with one or more setiferous punctures. . . . . *Holcaspis*  
 Mentum without such a pit on each side; 3rd elytral interval always without setiferous punctures. . . . . 6
- 6 (5) With a group of long setae on the prosternum; the setiferous punctures of the marginal series of the elytra numerous and regularly spaced, not grouped towards apex and base. . . . . *Plocamostethus* gen.n.  
 Without setae on the prosternum; the setiferous punctures of the marginal series of the elytra less than 20 in number, more closely grouped at apex and base than in the middle. . . . . *Neoferonia* gen.n.
- 7 (4) Pro-episterna finely striated; scutellar striae absent; striae unpunctured; striae 6 and 7 indistinct towards the base. . . . . *Rhytisternus*  
 Pro-episterna smooth; scutellar striae present at the base of the first interval; all striae equally distinct. . . . . 8
- 8 (7) Posterior face of the extremity of the prosternum not longitudinally compressed to form a sharp keel; upper surface of all tarsi bare. . . . . *Pseggmatopterus*  
 Posterior face of the extremity of the prosternum longitudinally compressed, forming a sharp vertical edge; upper surface of all tarsi pubescent. . . . . *Laemostenus*

## Genus MEGADROMUS Motchulsky.

Bull. Soc. Nat. Mosc., 1865, XXXVIII, IV, p. 249.

Genotype: *Megadromus antarcticus* (Chaudoir) = (*viridilimbatus* Motchulsky) loc. cit. (monotypic genus).*Trichosternus* Chaudoir, 1865, Bull. Soc. Nat. Mosc., XXXVIII, iii, p. 70 (in part).*Nesopterostichus* Tschitscherin, 1902, Horae Ent. Soc. Ross., XXXV, p. 521.*Pterostichus* Broun, 1893, Man. New Zeal. Col., V, p. 986 (non Steph.).

*Megadromus* was erected by Motchulsky in 1865 on one species, *M. viridilimbatus*, from New Zealand. This species had been described earlier in the same year by Chaudoir, who placed it in the Australian genus *Trichosternus* under the name *T. antarctica*. In 1902, Tschitscherin created the subgenus *Nesopterostichus* to include all New

Zealand species of the genus *Trichosternus*. This must include *Megadromus antarcticus* (Chaudoir), so that *Nesopterostrictus* Tschitsch. becomes a synonym of *Megadromus* Motch.

Examination of the species of *Megadromus*, however, shows that this cannot continue to be regarded as a subgenus of *Trichosternus*, for although the majority of the species have a group of setae on the extremity of the prosternum, like the Australian *Trichosternus*, they differ markedly in possessing a series of bristle-bearing punctures on the seventh elytral intervals. They differ also in that the setiferous punctures of the marginal series of elytra are well developed, whereas in the Australian *Trichosternus* they are greatly reduced. If the prosternal setae are to be considered of generic importance, correlated generic distinctions should be observed between the types of male genitalia of the two groups of species of *Megadromus*. Among the species of *Megadromus*, that is, those New Zealand species with a series of punctures on the seventh interval, there are forms with and others without prosternal setae. It follows that if the presence of prosternal setae is to be considered of generic importance, then correlated difference should be observed between these two groups of species. No such differences actually exist. There is no discontinuity between the types of the male genitalia of the two groups. The character given by the prosternal setae may therefore be discounted in favour of that of the series of punctures on the seventh interval. The species showing this character have a characteristic facies and distinct type of male genitalia. These species form the genus *Megadromus*.

*Generic Description:* Length 17–35 mm.; colour metallic green, aeneous, brown or black. The pronotum is transverse and usually more or less cordiform, normally with two setae in the marginal groove on each side, sometimes with four or five. The elytra are bordered at the base and the shoulders are dentate; striae obvious, faintly punctured; scutellar striole faint; intervals usually moderately convex, the third usually with at least three setiferous punctures. The majority of species have no punctures on the fifth interval. The seventh interval has always a series of setiferous punctures. The number of punctures on any one interval is variable. One or two punctures sometimes appear in the fifth interval, in individuals of species which are normally without (e.g. *M. sandageri*, *M. optabilis*). A group of setae is present on the extremity of the prosternum in about one half of the species.

The aedeagus is only slightly assymmetrical and the apex not expanded. The right (ventral *in situ*) paramere is usually hooked and is almost as long as the aedeagus. The left (dorsal) paramere is of the discoidal form usual in Pterostichini.

Hindwings are absent and the elytra are soldered together along the suture.

#### KEY TO THE SPECIES OF *Megadromus*.

- |   |   |   |
|---|---|---|
| 1 | With 4 or 5 setiferous punctures in the marginal groove on each side of the pronotum. . . . . | 2 |
|   | With 2 setiferous punctures in the marginal groove on each side of the pronotum. . . . .      | 4 |

- 2 (1) With no setiferous punctures on the 3rd elytral interval. *vigil* (White)  
With 2 or more setiferous punctures on the 3rd elytral interval. . . . . 3
- 3 (2) Very large, over 28 mm. long; the 3 setiferous punctures of the 5th interval situated in the apical half only; eyes small but projecting. . . . . *lobipes* (Bates)  
Smaller, less than 23 mm. long; the 4 setiferous punctures of the 5th interval not restricted to the apical half; eyes small and not projecting beyond the curve of the surface of the head. . . . . *turgidiceps* (Broun)
- 4 (1) Very large and robust; more than 28 mm. long; intervals 3, 5 and 7 twice as wide and much more convex than the others, broken into elongate bullae by the wide depressions in which are the setiferous punctures; the 5th interval with 4 or more punctures. . . . . *bullatus* (Broun)  
Smaller, usually less than 25 mm. in length; intervals 3, 5 and 7 not differing from the others in width and convexity; the 5th interval usually without setiferous punctures, but never with more than 3. . . . . 5
- 5 (4) Prosternum bearing a number of setae at its extremity; colour usually metallic green. . . . . 6  
Prosternum without setae; colour shining black or metallic. . . . . 7
- 6 (5) Colour bronze; elytra shining near the suture, dull towards the margins and apex; intervals strongly convex, the 5th usually with one or more setiferous punctures. . . . . *australasiae* (Guérin)  
Colour usually metallic green, especially at margins of pronotum and elytra; the 5th interval always without setiferous punctures. . . . . *antarcticus* (Chaudoir)  
group of species
- 7 (5) Elytral intervals quite flat, striae faint; the 5th elytral interval with 1 or 2 setiferous punctures; length 19 mm.; colour black. . . . . *vagans* (Broun)  
Elytral intervals more or less convex, never flat; striae well marked; the 5th elytral interval rarely with any setiferous punctures. . . . . 8
- 8 (7) Colour shining black; large, 25–28 mm. in length. . . . . *sandageri* (Broun)  
Colour metallic green, aeneous or coppery; smaller, 17–23 mm. in length. . . . . 9
- 9 (8) Elytral intervals strongly convex; sides of the pronotum strongly and uniformly curved from the apex almost to the base, where there is a sharp sinuation (fig. 73). . . . . *memes* (Broun)  
Elytral intervals slightly to moderately convex; sides of the pronotum with an elongate sinuation in front of the posterior angles, or straight; with no sinuation. 10
- 10 (9) Small, length 17–18 mm.; colour aeneous green; posterior angles of the pronotum rather obtuse; sometimes with a setiferous puncture in the middle of the 5th elytral interval. . . . . *optabilis* (Broun)  
Larger, length 18–23 mm.; colour dark metallic green, pronotum with coppery reflections; posterior angles of the pronotum square; the 5th elytral interval never with a setiferous puncture in the middle. . . . . 11
- 11 (10) Hook of the ventral paramere slender, long and slightly curved (fig. 23) . . . . . *fultoni* (Broun)  
Hook of ventral paramere very short, conical (fig. 24). *meritus* (Broun)

**Megadromus vigil** (White, 1846), in Richardson and Gray, *Voyage of the Erebus and Terror*, Ins., p. 3 (*Feronia*); Broun, 1880, *Man. New Zeal. Col.*, I, p. 41.

**Pterostichus difformipes** Bates, 1878, *Ent. Mo. Mag.*, 14, p. 191; Broun, 1880, *Man. New Zeal. Col.*, I, p. 33; G. V. Hudson, 1934, *New Zealand Beetles*, p. 35, pl. 1, figs. 3, 3a (larva) (n.syn.).

Figs. 5, 57.

Length: 20–23 mm. Colour: black or very dark metallic blue, sometimes with coppery reflections on the pronotum. Elytra with intervals moderately convex, the 7th with six setiferous punctures; striae not, or only very faintly punctured.

Localities: Port Nicholson, Wellington (C. M. Wakefield); Hastwell (H. Suter); Mount Dennan; Mount Holdsworth (G. V. Hudson). Twenty-seven examples.

**Megadromus lobipes** (Bates, 1878), *Ent. Mo. Mag.*, XIV, pp. 191, 196; Broun, 1880, *Man. New Zeal. Col.*, I, p. 34 (*Pterostichus*).

Fig. 6.

Length: 30 mm. Head large, eyes comparatively small but strongly convex. Pronotum cordiform, sides sinuate in front of the posterior angles which are square; each side bearing 4 or 5 setiferous punctures in the marginal groove; a single broad impression at the base on each side. Elytra rather flat, with well marked striae which are faintly punctured; scutellar striole present; intervals quite flat, surface with very strong isodiametric microsculpture, giving a dull appearance; 3rd interval with 4 setiferous punctures; 5th interval with 3 setiferous punctures in the apical half; 7th interval with 5 setiferous punctures; marginal series of about 25 setiferous punctures; shoulders with a blunt tooth; basal margin well marked; lateral margins wide and upturned. The extremity of the prosternum between the coxae is without setae.

Localities: Otira River, Westland (C. M. Wakefield), 1 ♂; Greymouth (Helms), 1 ♂.

**Megadromus turgidiceps** (Broun, 1908), *Ann. Mag. Nat. Hist.* (8), II, p. 409 (*Pterostichus*).

Figs. 7, 58.

Length: 17.5–20 mm. Colour: black.

Head large, mandibles elongate, almost as long as the head; eyes small, hardly projecting from the surface of the head. Pronotum relatively elongate (in the 20 mm. example, 4.95 mm. wide x 4.45 mm. long); sides with a rather long sinuation in front of the posterior angles which are square and blunt; a broad shallow impression at the base on either side; 4 setiferous punctures on each side in the marginal groove.

Elytra flat, with well marked striae which are faintly punctured; intervals moderately convex; surface with very strong isodiametric microsculpture; 3rd and 5th intervals each with 3 setiferous punctures; 7th elytral interval with 7 setiferous punctures; marginal series with about 19 setiferous punctures; basal margin well marked;

apex of elytra abruptly rounded off behind the apical sinuation; margins rather strong, reflexed. The extremity of the prosternum is without setae.

Locality: Manawatu Gorge, North Island (W. W. Smith), 1 ♂ 1 ♀.

**Megadromus bullatus** (Broun, 1915), *Bull. New Zeal. Inst.*, I, IV, p. 275; G. V. Hudson, 1934, *New Zealand Beetles*, p. 37 (*Pterostichus*).

Fig. 8.

Length: 28–30 mm. Colour: black, sometimes metallic green at sides.

Head large, eyes small but strongly convex. Pronotum strongly transverse (9 mm. wide x 5.5 mm. long); sides strongly curved outwardly from apex to base; posterior angles obtuse; 2 setiferous punctures in the marginal groove on each side. Elytra convex and very broad (16 mm. long x 11 mm. wide), striae faint and irregular; intervals slightly convex; surface with strong isodiametric microsculpture; intervals 3, 5 and 7 wider and more convex than the others; 3rd interval with 6–8 setiferous punctures; the 5th interval with 5 or 6 setiferous punctures; the 7th interval with 8 setiferous punctures; the depressions in which the setiferous punctures are set divide the 3rd, 5th and 7th intervals into irregular chains of elongate bullae. Prosternum without setae.

Locality: Greenstone Flat, near Queenstown, Otago (M. O. Pasco); Clinton River, near Lake Te Anau. 3 ♂ ♂, 2 ♀ ♀.

**Megadromus australasiae** (Guérin, 1841), *Rev. Zool.*, p. 121; (*Platysma*); White, 1846, in Richardson and Gray, *Voy. Erebus and Terror*, Ins., p. 3; Blanchard, 1853, *Voy. Pôle Sud*, IV, p. 31, t. 2, f. 13 (*Abax*).

*Trichosternus guerini* Chaudoir, 1865, *Bull. Soc. Nat. Mosc.*, 38, III, p. 75; Broun, 1880, *Man. New Zeal. Col.*, I, p. 32.

*Trichosternus akaroensis* Broun, 1903, *Ann. Mag. Nat. Hist.* (7), II, p. 603 (n.syn.).

Figs. 9, 59.

Length: 20–24 mm. Colour: aeneous-black.

Pronotum transverse (11 mm. wide x 7.5 mm. long in middle); sides each bearing two setiferous punctures. In the type of *T. akaroensis* Broun, the anterior puncture on the right side is duplicated. The sides in front of the posterior angles are scarcely sinuate. Elytra unusually depressed, with intervals convex throughout their whole length; isodiametric microsculpture strongly developed towards the margins and apex, so that the basal and middle parts of the elytra are shining, and the marginal and apical parts dull. The striae are well marked and quite strongly punctured. The 3rd interval with 3–5 setiferous punctures; the 5th interval with 1 or 2 setiferous punctures; the 7th interval with 4–6 setiferous punctures; the punctures on the 5th interval are variable, for in 3 of 20 examples examined they are entirely absent, while in others they are assymmetrical, e.g. the left elytron with 2 and the right with 1 puncture.

Localities: Akaroa; Timaru; Otago. 20 examples.

## THE antarcticus GROUP OF SPECIES.

It is not possible to make a satisfactory key to these eleven closely allied species. The most certain method of identification is by comparison of the male genitalia with the figures. The pronotum shows rather subtle specific differences in shape.

**Megadromus antarcticus** (Chaudoir, 1865), *Bull. Soc. Nat. Mosc.*, 38, III, p. 73 (*Trichosternus*); Bates, 1874, *Ann. Mag. Nat. Hist.* (4), 13, p. 242; Broun, 1880, *Man. New Zeal. Col.*, I, p. 31; G. V. Hudson, 1934, *New Zealand Beetles*, p. 36.

*Megadromus viridilimbatus* Motschulsky, 1865, *Bull. Soc. Nat. Mosc.*, 38, iv, p. 251.

*Trichosternus crassalis* Broun, 1893, *Man. New Zeal. Col.*, VII, p. 1395; *Trans. New Zeal. Inst.*, 1893, XXV, p. 195 (n.syn.).

*Trichosternus coelocephalus* Broun, 1908, *Ann. Mag. Nat. Hist.* (8), II, p. 405 (n.syn.).

*Trichosternus dissentaneus* Broun, 1910, *Bull. New Zeal. Inst.*, I, i, p. 6 (n.syn.).

*Trichosternus blandellus* Broun, 1915, *Bull. New Zeal. Inst.*, I, iv, p. 274 (n.syn.).

Figs. 1, 10, 60.

Length: 22–34 mm. Colour: aeneous black-greenish, margins of pronotum and elytra bright metallic green.

Pronotum with sides not sinuate above the posterior angles which are obtuse; elytral intervals convex, the 3rd, 5th and 7th rather wider and more convex than the others; striae well marked but hardly punctured; the 3rd interval with 3 or 4 setiferous punctures; the 7th interval with 6 setiferous punctures.

Localities: Bealey; Christchurch; Canterbury. 52 examples.

**Megadromus virens** (Broun, 1886), *Man. New Zeal. Col.*, IV, p. 937 (*Trichosternus*).

*Trichosternus hampdenensis* Broun, 1893, *op. cit.* VI, p. 1323 (n.syn.).

Figs. 11, 61.

Length: 19–22 mm. Colour: aeneous-black-greenish, margins of pronotum and elytral bright metallic green.

Sides of the pronotum with an elongate sinuation in front of the posterior angles which are very slightly acute. Elytral intervals moderately convex, the 3rd, 5th and 7th somewhat wider and more convex than the others; striae obvious but punctuation obsolete; the 3rd interval with 3 or 4 and the 7th interval with 4 setiferous punctures.

Localities: Oamaru (T. Chalmer), 1♂, 1♀; Hampden, Otago, 1♂.

**Megadromus enysi** (Broun, 1882), *New Zeal. Journ. Sci.*, p. 221 (*Trichosternus*); *Man. New Zeal. Col.*, 1886, III, p. 752.

*Trichosternus walkeri* Broun, 1903, *Ann. Mag. Nat. Hist.* (7), XI, p. 602 (n.syn.).

*Trichosternus halli* Broun, 1914, *Bull. New Zeal. Inst.*, I, iii, p. 149 (n.syn.).

Figs. 12, 62.

Length: 20–23 mm. Colour: dark metallic blue or aeneous.

Sides of the pronotum with a long sinuation in front of the posterior angles which are rectangular; elytral intervals very slightly convex, more so near the margins; striae well marked, punctuation obsolete; the 3rd interval with 3 and the 7th with 5 setiferous punctures.

Localities: Wellington, Mount Hutt; Westland, Otira Gorge. 7 examples.

**Megadromus capito** (White, 1846), in Richardson and Gray, *Voyage Erebus and Terror*, Ins., p. 4 (*Feronia*); Chaudoir, 1865, *Bull. Soc. Nat. Mosc.*, 38, III, p. 74; Broun, 1880, *Man. New Zeal. Col.*, I, p. 32.

*Trichosternus aucklandicus* Bates, 1878, *Ent. Mo. Mag.*, XV, p. 25 (n.syn.).

*Trichosternus aucklandicus* Broun, 1880, *Man. New Zeal. Col.*, I, p. 32.

*Trichosternus humeralis* Broun, 1882, *New Zeal. Journ. Sci.*, I, p. 220; *Man. New Zeal. Col.* III, 1886, p. 750 (n.syn.).

*Trichosternus cephalotes* Broun, 1886, *Man. New Zeal. Col.*, IV, p. 825; G. V. Hudson, 1934, *New Zealand Beetles*, p. 36 (n.syn.).

*Trichosternus bucolicus* Broun, 1903, *Ann. Mag. Nat. Hist.* (7), XI, p. 604 (n.syn.).

*Trichosternus hudsoni* Broun, 1904, *Ann. Mag. Nat. Hist.* (7), XIV, p. 44 (n.syn.); G. V. Hudson, 1934, *New Zealand Beetles*, p. 36.

*Trichosternus ordinarius* Broun, 1908, *Ann. Mag. Nat. Hist.* (8), II, p. 407 (n.syn.).

Figs: 13, 63.

Length: 18–23 mm. Colour: metallic green or blue; elytra aeneous on the disc; pronotum comparatively straight sided, only slightly sinuate in front of the posterior angles which are slightly obtuse; elytral intervals strongly convex, the 3rd with 4 or 5, and the 7th with 5 setiferous punctures.

Localities: Auckland, Rangiriri, Ohakune, Hicks' Bay, Manawatu Gorge, Lake Horowhenua, Wellington, Stephens Island. 45 examples.

**Megadromus temukensis** (Bates, 1878), *Ent. Mo. Mag.* XV, p. 26 (*Trichosternus*); Broun, 1880, *Man. New Zeal. Col.*, I, p. 34.

*Trichosternus sylvius* Bates, 1878, *Ent. Mo. Mag.* XV, p. 26; Broun, 1880, *Man. New Zeal. Col.* I, p. 35 (n.syn.).

*Trichosternus smithii* Broun, 1893, *Man. New Zeal. Col.*, VI, p. 1322 (n.syn.).

Figs. 14, 64.

Length: 18–20 mm. Colour: metallic blue, green or aeneous.

Pronotum with sides slightly sinuate in front of the posterior angles; elytra with the intervals convex, 3rd with 3 or 4 and the 7th with 4 setiferous punctures.

Localities: Ashburton (W. W. Smith), Peel Forest (C. M. Wakefield), Timaru (J. J. Walker), Canterbury.

**Megadromus rectalis** (Broun, 1881), *Man. New Zeal. Col.*, II, p. 656 (*Trichosternus*).

Figs. 15, 65.

Length: 20 mm. Colour: black.

Pronotum with the hind angles flat and prominent, sharp and slightly acute. Elytra with shoulders strongly dentate; intervals only slightly convex; 3rd interval with 4 and 7th with 5 setiferous punctures.

Locality: Nelson (T. F. Cheeseman). Known from a unique male.

**Megadromus alternus** (Broun, 1886), *Man. New Zeal. Col.*, IV, p. 877 (*Trichosternus*).

*Trichosternus urquharti* Broun, 1886; *loc. cit.*, p. 877 (n.syn.).

Figs: 16, 66.

Length: 18-19 mm. Colour: brownish-black.

Elytral intervals strongly convex; striae obvious; punctuation obsolete; microsculpture of surface not obvious; 3rd interval with 3 or 4 and 7th with 6 setiferous punctures.

Locality: mountains near Lake Tekapo, South Island (T. F. Cheeseman and A. T. Urquhart), 3 ♂ ♂.

**Megadromus compressus** (Sharp, 1886), *Trans. R. Dublin Soc.* (2) III, p. 366, plate 12, f. 6 (*Trichosternus*).

Figs. 17, 67.

Length: 18-22 mm. Colour: aeneous, metallic green at borders of pronotum and elytra. Sides of pronotum not or only very slightly sinuate in front of the posterior angles, which are square. Elytral intervals moderately convex, the 3rd with 3 and 7th with 4-6 setiferous punctures.

Locality: Picton (Helms), 5 ♂ ♂, 2 ♀ ♀.

**Megadromus hanmerensis** (Broun, 1908), *Ann. Mag. Nat. Hist.* (8) II, p. 406 (*Trichosternus*).

Figs. 18, 68.

Length: 20-24 mm. Colour: aeneous-black.

Sides of pronotum rather straight, with an elongate sinuation in front of the posterior angles which are square. Elytral intervals slightly convex, the 3rd with 3 punctures, the 7th with 5 punctures; striae well marked, punctuation obsolete.

Localities: Hanmer, Mount Algidus, Canterbury. 1 ♂, 2 ♀ ♀.

**Megadromus rectangulus** (Chaudoir, 1865), *Bull. Soc. Nat. Mosc.*, 38, III, p. 74 (*Trichosternus*); Broun, 1880, *Man. New Zeal. Col.*, I, p. 35.

*Trichosternus wallacei* Broun, 1912, *Trans. New Zeal. Inst.*, 44, p. 390 (n.syn.).

Figs. 19, 69.

Length: 22-24 mm. Colour: black.

Sides of pronotum comparatively straight, not sinuate in front of the posterior angles which are square. Elytral intervals slightly

convex, becoming more so towards the margins, the 3rd with 3, the 7th with 6 setiferous punctures.

Localities: Christchurch (J. J. Walker); Kaikoura; Clarence Bridge (G. V. Hudson); Puhupuhi (G. V. Hudson); Wairiri (W. L. Wallace). 8♂♂, 2♀♀.

**Megadromus haplopus** (Broun, 1893), *Man. New Zeal. Col.*, VI, p. 1323 (*Trichosternus*).

Figs. 20, 70.

Length: 23 mm. Colour: brownish black.

Sides of the pronotum obviously sinuate in front of the posterior angles which are square but rather blunt. Elytral intervals moderately convex, the 3rd with 3 or 4 punctures and the 7th with 5; striae unpunctured.

Locality: Hampden, Otago (P. Sandager), 1♂, 1♀.

**Megadromus vagans** (Broun, 1886), *Man New Zeal. Col.*, III, p. 825 (*Trichosternus*).

Fig. 71.

Length: 19 mm. Colour: shining black.

Pronotum transverse (5.9 mm. wide x 3.8 mm. long in middle); each side bearing two setiferous punctures, strongly sinuate in front of the posterior angles which are approximately square. Elytra with intervals quite flat on the disc, becoming slightly convex towards apex, base and margins; striae faint, minutely and indistinctly punctured; scutellar striae present; 3rd interval with 3 or 4 setiferous punctures; 5th interval with 3 and 7th with 5 setiferous punctures.

Locality: Mount Maungatua, Otago (S. W. Fulton). Known only from a single ♀.

**Megadromus sandageri** (Broun, 1893), *Man. New Zeal. Col.*, V, p. 988 (*Pterostichus*); G. V. Hudson, 1934, *New Zealand Beetles*, p. 36.

*Pterostichus oneroaensis* Broun, 1908, *Ann. Mag. Nat. Hist.* (8), II, p. 413; G. V. Hudson, 1934, *New Zealand Beetles*, p. 36 (n.syn.).

*Pterostichus hamiltoni* Broun, 1912, *Trans. New Zeal. Inst.*, 44, p. 390 (n.syn.).

*Pterostichus pascoi* Broun, 1915, *Bull. New Zeal. Inst.*, I, iv, p. 275 (n.syn.).

*Pterostichus aciphyllae* Broun, 1917, *Bull. New Zeal. Inst.*, I, p. 361 (n.syn.).

Figs. 21, 72.

Length: 25–28 mm. Colour: black.

Elytra with intervals moderately convex; the 3rd with 3 or 4 and the 7th with 5 setiferous punctures. Of the 25 examples which I have examined, 14 have no setiferous punctures on the 5th intervals. The remaining 11, including the type, have a variable number (1–3) of setiferous punctures on the 5th intervals, and the number of punctures is rarely the same on the left and right. The type of *M. sandageri* has 3 punctures on the 5th interval of the left elytron.

and 2 punctures on the right. I regard the examples without any punctures on the 5th intervals as belonging to this species because the male genitalia are indistinguishable from those of the type.

Localities: Puysegur Point (P. Sandager); Te Oneroa (P. Seymour); Invercargill (F. Hudson); Bold Peak (6,000 ft.), Wakatipu (H. Hamilton); Ben Lomond, Wakatipu (M. O. Pasco); Clipping's Bush, 2,500 ft., near Kingston (T. Hall).

**Megadromus memes** (Broun, 1903), *Ann. Mag. Nat. Hist.* (7), XI, p. 605 (*Pterostichus*).

Figs. 22, 73.

Length: 18–20 mm. Colour: metallic green or aeneous.

Elytral intervals very strongly convex, the 3rd with 3 or 4 and the 7th with 4 setiferous punctures; striae well marked, faintly punctured. The close relation of this and *M. fultoni* is shown by the similarity of the male genitalia.

Locality: Maniototo Plains (J. H. Lewis), 17 examples.

**Megadromus optabilis** (Broun, 1893), *Man. New Zeal. Col.*, V, p. 986 (*Pterostichus*). New name for:

*Trichosternus erythropus* Broun, 1884, *New Zeal. Journ. Sci.*, II, p. 226; *Man. New Zeal. Col.*, IV, 1886, p. 913 (nec. Marsh, Dejean, Villa, Fald).

*Trichosternus curtulus* Broun, 1884, *New Zeal. Journ. Sci.*, II, p. 227; *Man. New Zeal. Col.* IV, 1886, p. 916 (n.syn.).

*Trichosternus suspicax* Broun, 1884, *New Zeal. Journ. Sci.*, II, p. 227; *Man. New Zeal. Col.*, IV, 1886, p. 917 (n.syn.).

Fig. 74.

Length: 17–18 mm. Colour: aeneous-black, the pronotum with coppery and bluish reflections.

Pronotum with the sides not or scarcely sinuate in front of the posterior angles which are rather obtuse. Elytral intervals moderately convex, the 3rd with 2 or 3, and the 7th with 4–6 setiferous punctures. The type of *M. optabilis* has one setiferous puncture near the middle of the 5th interval.

Locality: Rock and Pillar Mountains, Otago (S. W. Fulton), 3 ♀♀.

**Megadromus fultoni** (Broun, 1882), *New Zeal. Journ. Sci.*, I, p. 221 (*Trichosternus*); *Man. New Zeal. Col.*, III, 1886, p. 751.

*Pterostichus erraticus* Broun, 1884, *New Zeal. Journ. Sci.*, II, p. 227; *Man. New Zeal. Col.*, IV, 1886, p. 915 (n.syn.).

*Pterostichus amplicollis* Broun, 1884, *New Zeal. Journ. Sci.*, II, p. 227; *Man. New Zeal. Col.*, IV, 1886, p. 918 (n.syn.).

*Trichosternus curvipes* Broun, 1886, *Man. New Zeal. Col.*, IV, p. 878 (n.syn.).

*Trichosternus polychaetus* Broun, 1893, *Man. New Zeal. Col.*, V, p. 987 (n.syn.).

*Pterostichus flectipes* Broun, 1908, *Ann. Mag. Nat. Hist.* (8), II, p. 413 (n.syn.).

Figs. 23, 75.

Length: 18–22 mm. Colour: aeneous black; often metallic green or coppery in the basal foveae and around the margins of pronotum

and elytra. Elytral intervals slightly convex, the 3rd with 3 or 4 and the 7th with 4 or 6 setiferous punctures. Of the 13 examples in the British Museum, one, the type of Broun, has 3 short setae on the posterior face of the prosternum.

Locality: Taieri (S. W. Fulton), 7 ♂ ♂, 4 ♀ ♀.

**Megadromus meritus** (Broun, 1884), *New Zeal. Journ. Sci.*, II, p. 227 (*Trichosternus*); *Man. New Zeal. Col.*, IV, 1886, p. 914.

*Trichosternus angulatus* Broun, 1884, *New Zeal. Journ. Sci.* II, p. 227; *Man. New Zeal. Col.*, IV, 1886, p. 914 (n.syn.).

*Trichosternus agriotes* Broun, 1884, *New Zeal. Journ. Sci.*, II, p. 227; *Man. New Zeal. Col.*, IV, 1886, p. 915 (n.syn.).

*Trichosternus waihourensis* Broun, 1886, *Man. New Zeal. Col.*, IV, p. 821 (n.syn.).

*Trichosternus monticola* Broun, 1886, *Man. New Zeal. Col.*, IV, p. 821 (n.syn.).

*Trichosternus aeruginosus* Broun, 1886, *Man. New Zeal. Col.*, IV, p. 822 (n.syn.).

*Trichosternus chloris* Broun, 1886, *Man. New Zeal. Col.*, IV, p. 823 (n.syn.).

*Trichosternus grassator* Broun, 1886, *Man. New Zeal. Col.*, IV, p. 823 (n.syn.).

*Trichosternus fusulus* Broun, 1886, *Man. New Zeal. Col.*, IV, p. 824 (n.syn.).

*Pterostichus deceptus* Broun, 1886, *Man. New Zeal. Col.*, IV, p. 916 (new name for *P. riparius* Broun (not of Dejean), *New Zeal. Journ. Sci.*, II, 1884, p. 227) (n.syn.).

*Pterostichus meliusculus* Broun, 1893, *Man. New Zeal. Col.*, V, p. 986 (new name for *P. convexus* Broun (not of Gebler), 1884, *New Zeal. Journ. Sci.*, II, p. 227) (n.syn.).

*Pterostichus amicus* Broun, 1893, *Man. New Zeal. Col.*, V, p. 986 (n.syn.).

*Pterostichus kirkianus* Broun, 1903, *Ann. Mag. Nat. Hist.* (7), XI, p. 604 (n.syn.).

*Pterostichus maiaei* Broun, 1917, *Bull. New Zeal. Inst.*, I, p. 363 (n.syn.).

Figs. 24, 76.

Length: 20–23 mm. Colour: metallic aeneous-green or blue, the margins of pronotum and elytra usually metallic green.

Elytral intervals slightly convex, 3rd interval with 3 or 4, and 7th with 4 to 6 setiferous punctures.

Localities: Taieri, bed of Lee Stream (S. W. Fulton); Mount Maungatua, Taieri; Waihoua, Bruce County, Otago (S. W. Fulton); Invercargill (T. Chalmer). 29 examples.

#### Genus ZEOPŒCILUS Sharp.

*Zeopœcilus* Sharp, 1886, *Trans. R. Dublin Soc.*, II, 3, p. 365.

Genotype: *Zeopœcilus calcaratus* Sharp, 1886, *loc. cit.* (present selection).

Length, 20 to 24 mm. Apterous, elytra joined along suture. Colour bronze or aeneous, the pronotum showing coppery and green reflections; legs and antennae piceous, the latter paler towards their apices.

Sides of the prothorax strongly curved outwards in the middle and sinuate towards the base; posterior angles approximately rectangular; each side of the pronotum with two setiferous punctures, one just before the middle, the other at the posterior angle; basal foveae large and deep, reaching the base near the angle.

Elytra with shoulders strongly dentate; striae well impressed and faintly punctured; intervals convex, shining in ♂♂, dull in ♀♀; no punctures on the 3rd, 5th and 7th intervals; the 8th interval narrowed apically to form a ridge which almost reaches the sutural angle.

Prosternum, between coxae, without setae; mesepisternum faintly punctured; one setiferous puncture on each side of the apical sternite of the abdomen in the male, two on each side in the female. The genus is distinguished on the following characters. The basal segment of the antenna is flattened on the dorsal side in both sexes. In the male the basal segment of the posterior tarsi is compressed, and the inner side of apex of the posterior tibiae is prolonged. The aedeagus is expanded at the apex and the dorsal paramere is reduced to less than one half the length of the aedeagus. It forms a plate, rounded at the apex, narrowed at the base, with no trace of an apical hook.

Two species are known:—

Apical prolongation of the posterior tibiae in ♂ tapered to a point; the basal segment of the posterior tarsi only slightly compressed; aedeagus broad at the apex (see fig. 25). .. *calcaratus* Sharp  
Apical prolongation of the posterior tibiae in ♂ obliquely truncate; the basal segment of the posterior tarsi strongly and obliquely compressed; aedeagus narrow at apex (see fig. 26). .. .. . *putus* (Broun)

***Zeopoecilus calcaratus*** Sharp, 1886, *Trans. R. Dublin Soc.*, II, 3, p. 366, t. 12, f. 7; Broun, 1893, *Man. New Zeal. Col.*, V, 1893, p. 989.

Fig. 25.

Localities: Pieton (Helms); Flora R., Graham R., Mount Arthur, Nelson (G. V. Hudson). 18 examples.

***Zeopoecilus putus*** (Broun, 1882), *New Zeal. Journ. Sci.*, I, p. 219 (*Trichosternus*); *Man. New Zeal. Col.*, III, 1886, p. 750; *op. cit.*, V, 1893, p. 990.

***Zeopoecilus opulentus*** (Broun, 1886), *Man. New Zeal. Col.*, IV, p. 820 (*Trichosternus*) (n.syn.).

***Zeopoecilus achilles*** Sharp, 1886, *Trans. R. Dublin Soc.* (2), III, p. 367; Broun, 1893, *Man. New Zeal. Col.*, V, p. 990 (n.syn.).

***Zeopoecilus optandus*** Broun, 1908, *Ann. Mag. Nat. Hist.* (8), II, p. 408; G. V. Hudson, 1934, *New Zealand Beetles*, p. 36 (n.syn.).

***Trichosternus combesi*** Broun, 1882, *New Zeal. Journ. Sci.*, I, p. 220; *Man. New Zeal. Col.*, III, 1886, p. 750 (n.syn.).

I have not seen the type of this species, which must be in New Zealand, but the description is identical with that of *Zeopoecilus putus* Broun. The two "species" were obtained together on Mount Arthur; Broun obviously described the males as *putus* and the females as *combesi*.

Figs. 26, 77.

Localities: Picton (Helms); Mount Arthur (T. F. Cheeseman and F. Combes); Wangapeka Valley, Nelson (T. F. Cheeseman); Nelson (G. V. Hudson). 14 examples.

Genus *AULACOPODUS* nov.

Genotype: *Aulacopodus sharpianus* (Broun).

Without setiferous punctures on the 5th and 7th intervals; basal segments of the antennae normal; mentum with a deep pit on each side near the base; all tarsi grooved dorsally; striae evenly impressed and unpunctured; scutellum quite plane; scutellar striae well marked.

KEY TO THE SPECIES.

- 1 With a setiferous puncture at the posterior angle on each side of the pronotum .. .. . 2  
Without a setiferous puncture at the posterior angle of the pronotum. .. .. . *calathoides*
- 2 (1) With one or more setiferous punctures on the 3rd elytral interval; basal angles of the pronotum about rectangular. .. .. . 3  
With no setiferous punctures on the 3rd elytral interval; basal angles of the pronotum obtuse. .. .. . *sharpianus*
- 3 (2) With one or two setiferous punctures on the 3rd elytral interval; situated just anterior to the mid point of the interval; basal depressions of the pronotum unpunctured. .. .. . *maorinus*  
With 3 setiferous punctures on the 3rd elytral interval; basal impressions of the pronotum punctured. .. .. . *brouni* (Csiki)

*Aulacopodus calathoides* (Broun, 1886), *Man. New Zeal. Col.*, IV, p. 879 (*Haptoderus*).

Fig. 3.

Length: 10–12 mm. Colour: head, pronotum and elytra piceous, the pronotum reddish at the edges; legs, palpi and antennae reddish, paler distally.

Elytra fused along the suture; hindwings vestigial. The sides of the pronotum are uniformly curved outwards from apex to base; widest in the middle with no trace of sinuation basally.

Localities: Whangarata, near Tuakau; Ngaruawahia, Waikato; Kerikeri; Huia; Hunua; Ligar's Bush, Papakura; Titirangi. 11 examples.

*Aulacopodus sharpianus* (Broun, 1893), *Ann. Mag. Nat. Hist.* (6), XII, p. 163 (*Pterostichus*).

Fig. 27.

Length: 9 mm. Colour: piceous-black; palpi, legs and antennae reddish.

The sides of the pronotum are scarcely sinuate before the hind angles which are blunt and obtuse. Hindwings present but much reduced, elytra free.

Localities: Ohaupo

**Aulacopodus maorinus** (Bates, 1874), *Ann. Mag. Nat. Hist.* (4), XIII, p. 244 (*Haptoderus*).

Length: 7 mm. Colour: piceous; palpi, legs and antennae reddish.

The more posterior of the two setiferous punctures on the third interval may be absent on one side. Hindwings vestigial; elytra fused along suture.

Localities: Riccarton, Christchurch, Canterbury. 3 examples.

**Aulacopodus brouni** (Csiki, 1930), *Coleopt. Cat.*, p. 545.

*adoxus* Broun, 1908, *Ann. Mag. Nat. Hist.* (8), II, p. 414 (*Pterostichus*)

Fig. 28.

Length: 8–9 mm. Colour: piceous-black; palpi, legs and antennae reddish.

The basal depressions of the pronotum are broad and punctured; posterior angles rectangular. Hindwings present, reduced to one half length of elytra; elytra free.

Locality: Manawatu Gorge. 5 examples.

#### Genus *HOLCASPIIS* Chaudoir.

*Holcaspis* Chaudoir, 1865, *Bull. Soc. Nat. Mosc.*, 38, III, p. 101;

Broun, 1880, *Man. New Zeal. Col.*, I, p. 31; Tschitscherin, 1890, *Horae Soc. Ent. Ross.*, XXV, p. 162.

*Pterostichus* Broun, 1893, *Man. New Zeal. Col.*, V, p. 990 (non Steph.).

Genotype: *Holcaspis angustula* Chaudoir, 1865, *loc. cit.* (present selection).

This genus includes about one half of the indigenous species of Pterostichini. They are uniformly small and black, usually less than 15 mm. in length, distinguishable from the other native genera by the absence of setiferous punctures on the seventh elytral interval, the lack of depression of the first joint of the antenna, the absence of grooves on the tarsi and by the possession of two deep pits on the mentum (Fig. 74). These pits have bristles on their sides, and a membranous, unchitinised area at the bottom.

*Holcaspis* was originally distinguished by Chaudoir on the plurisulcate scutellum and the absence of grooves on the tarsi, but these characters are useless as they apply equally well to species of *Megadromus*. Broun abandoned the use of the name for this reason and placed all the species in *Pterostichus*. Sharp (1886, *Trans. R. Dublin Soc.* (2), III, p. 365) divided these species into groups on the number of setae on each side of the pronotum and in this he was followed by Broun. Examination shows that the number of setae bearing punctures on the pronotum is not always constant in those species with more than two on each side, and in some cases they are not even symmetrical. It seems obvious that the multiplication of setae on the sides of the pronotum is secondary and cannot be given any high taxonomic importance.

Hindwings are absent and the elytra united along the suture.

## KEY TO THE SPECIES.

- 1 With 2 setiferous punctures on each side of the pronotum. . . . . 2  
 With 3-6 setiferous punctures on each side of the pronotum. . . . . 9
- 2 (1) With one or more setiferous punctures on the 3rd elytral interval; pronotum with only one basal impression on each side. . . . . 3  
 With no setiferous punctures on the 3rd elytral interval; pronotum with a double basal impression on each side. . . . . 6
- 3 (2) Posterior angles of the pronotum completely rounded off. . . . . 4  
 Posterior angles of the pronotum sharp, approximately rectangular. . . . . 5
- 4 (3) Elytral intervals only slightly convex; striae punctured. . . . . *ovatella* Chaudoir  
 Elytral intervals very convex; striae unpunctured. . . . . var. *perbona*
- 5 (3) Elytral intervals flat; 3 setiferous punctures on the 3rd interval. . . . . Broun  
 Elytral intervals very convex; only one setiferous puncture on the 3rd interval, in the apical half. . . . . *sternalis* Broun  
*mordax* Broun
- 6 (3) Striae faint and irregular, forming wavy lines which occasionally unite laterally, dorsal paramere in ♂ spatulate, not hooked (see fig. 32); hind femur in ♂ without a tooth in the middle of the posterior side. . . . . *impiger* Broun  
 Striae more deeply impressed, regular, forming straight parallel lines; dorsal paramere hooked; hind femur in ♂ with or without a tooth in the middle of the posterior side. . . . . 7
- 7 (6) Hind femur in ♂ with a tooth in the middle of the posterior side. . . . . 8  
 Hind femur in ♂ without a tooth in the middle of the posterior side (locality, Mount Algidus). . . . . *algida* n.sp.
- 8 (7) Pronotum obviously transverse (fig. 84); elytra uniformly curved, widest in the middle; elytral striae usually faintly punctured, blade of aedeagus with an angle at one side. . . . . *angustula* Chaudoir  
 Pronotum more elongate (fig. 85); elytra widest one-fifth of their length from base; elytral striae unpunctured; blade of aedeagus rounded, without sharp angles. . . . . *longiformis* (Sharp)
- 9 (1) Pronotum with the posterior angles completely rounded off. . . . . 10  
 Pronotum with the posterior angles approximately rectangular, sharp. . . . . 12
- 10 (9) With no setiferous punctures on the 3rd elytral interval. . . . . 11  
 With 2 or 3 setiferous punctures on the 3rd elytral interval. . . . . *catenulata* Broun
- 11 (10) Large, over 17 mm. in length; basal margin of the elytra completely effaced; posterior femur of ♂ with a tooth in the middle of the posterior side. . . . . *brouniana* (Sharp)  
 Smaller, less than 15 mm. in length; basal margin of elytra reaching the 3rd stria; posterior femur of ♂ without a tooth. . . . . *elongella* (White)
- 12 (9) Two or more setiferous punctures on the 3rd elytral interval. . . . . 13  
 No setiferous punctures on the 3rd interval. . . . . 15

- 13 (12) Intervals quite flat, striae faint, punctured; 2 setiferous punctures in the apical half of the 3rd interval; body very convex; pronotum without distinct marginal groove; a single basal impression on each side of pronotum. . . . . *egregialis* (Broun)  
 Intervals moderately convex, striae obvious, indistinctly punctured; 3-6 setiferous punctures on the 3rd interval; body moderately convex; pronotum with a marginal groove; a double basal impression on each side of the pronotum. . . . . 14
- 14 (13) With 3 or 4 setiferous punctures on the 3rd interval close to the 3rd stria; pronotum contracted basally, posterior angles obtuse. . . . . *hudsoni* n.sp.  
 With 5 or 6 setiferous punctures on the 3rd interval close to the 3rd stria; pronotum hardly contracted basally; posterior angles square and prominent. . . . . *suteri* Broun
- 15 (12) Intervals 3, 5 and 7 each twice as wide as intervals 4 and 6 and much more convex; apical sinuation of the elytral very abrupt forming a deep rectangular notch; striae unpunctured. . . . . *dentifera* (Broun)  
 All intervals approximately equal in width and convexity; apical sinuation of elytral not unusually deep. . . . . 16
- 16 (15) With the basal margin of the elytra completely obsolete. . . . . 17  
 With the basal margin of the elytra in the form of a raised transverse ridge. . . . . 18
- 17 (16) With 5 setiferous punctures on each side of the pronotum; posterior angles of the pronotum very obtuse; femora greatly expanded and swollen; with a tooth in the middle of the inner margin of the posterior tibia; terminal blade of the aedeagus symmetrical with an emargination at the apex. . . . . *odontella* (Broun)  
 With 4 setiferous punctures on each side of the pronotum; posterior angles obtuse or rectangular; femora and tibiae normal; aedeagus asymmetrical, not emarginate at apex. . . . . *hispidula* (Broun)
- 18 (16) Sides of pronotum not sinuate in front of the posterior angles which are obtuse; elytral striae much interrupted along their whole length. . . . . *oedionema* Bates  
 Sides of pronotum sinuate in front of the posterior angles which are square or even acute; elytral striae usually continuous. . . . . 19
- 19 (18) Pronotum elongate, considerably constricted basally (see fig. 96); shoulders of the elytra completely rounded off; apex of inner edge of posterior tibia in ♂ produced into a long point. . . . . *muoronata* Broun  
 Pronotum more transverse; shoulders of elytra more or less prominent; apex of posterior tibia in ♂ not produced into a point. . . . . 20
- 20 (19) Posterior tibiae quite straight (South Island). . . . . *delator* (Broun)  
 Posterior tibiae distinctly curved (North Island) . . . . . 21
- 21 (20) Shape of thorax as in fig. 98; elytra with at least 23 setiferous punctures in the marginal series, on each side; basal margin of elytra extending from shoulders only as far as base of the 4th stria, broken or very irregular beyond this point. . . . . *subaenea* (Guérin)  
 Shape of thorax as in figs. 99 and 100; elytra with 17 setiferous punctures at most, in the marginal series on each side; basal margin of elytra extending in a straight unbroken line from shoulder to the base of the scutellar striae. . . . . 22

- 22 (21) Sides of the pronotum with a very short sinuation just in front of the posterior angles (see fig. 99); elytral intervals only slightly convex; striae unevenly impressed and indistinctly punctured. . . *vagèpunctata* (White)  
 Sides of the pronotum with a long sinuation in front of the post. angles (see fig. 100); elytral intervals strongly convex; striae evenly impressed and regularly punctured. . . *sinuiventris* (Broun)

**Holcaspis ovatella** Chaudoir, 1865, *Bull. Soc. Nat. Mosc.*, XXXVIII, 3, p. 105; Sharp, 1886, *Trans. R. Dublin Soc.* (2), III, p. 370 (*Pterostichus*); Broun, 1880, *Man. New Zeal. Col.*, I, p. 39; *loc. cit.*, V, 1893, p. 995 (*Pterostichus*).

Figs. 29, 79.

Length: 15–18 mm.

The posterior angles of the pronotum are completely rounded off and so are almost exactly similar to the anterior angles. The shoulders of the elytra are also rounded off and show no sign of a tooth. The striae are strongly impressed and closely punctured. There are three setiferous punctures on the third interval.

Localities: Canterbury; Mount Griffel, south of Lake Wanaka (C. E. Clarke); Invercargill (Lewis). 3 ♂♂, 2 ♀♀.

**Holcaspis ovatella** Chaud. subsp. **perbonus** (Broun, 1908) *Ann. Mag. Nat. Hist.* (8), II, p. 418 (*Pterostichus*).

Length: 15–16 mm.

Differing from *H. ovatella* Chaud. only in having the intervals strongly convex and the striae unpunctured. The ♂ genitalia are so similar in the two forms that it is hardly possible to regard them as being specifically distinct.

Locality: Otago (Lewis). 13 examples.

**Holcaspis sternalis** Broun, 1881, *Man. New Zeal. Col.*, II, p. 658.

*Cerabilia punctigerus* Broun, 1882, *New Zeal. Journ. Sci.*, I, p. 223; *Man. New Zeal. Col.*, III, 1886, p. 753 (n.syn.).

*Pterostichus oscillator* Sharp, 1886, *Trans. R. Dublin Soc.* (2), III, p. 369 (*Pterostichus*) Broun, 1893, *Man. New Zeal. Col.*, V, p. 995 (n.syn.).

*Pterostichus perfidiosa* Broun, 1893, *Man. New Zeal. Col.*, V, p. 995 (n.syn.).

*Pterostichus lepidulus* Broun, 1908, *Ann. Mag. Nat. Hist.* (8) II, p. 419 (n.syn.).

*Pterostichus melanostolus* Brookes, 1926, *Trans. and Proc. New Zeal. Inst.*, LVI, p. 443 (n.syn.).

Figs. 30, 80.

Length: 12–13 mm.

Basal foveae of the pronotum deep and elongate, extending from the middle of the disc on each side. Elytral intervals flat; striae unpunctured; three setiferous punctures on the third interval.

Localities: Akaroa; Mt. Dick, Otago; Dunedin; Port Chalmers; Invercargill. The type locality of *H. sternalis* is given as Whangarei Harbour, but the specimen in the Broun collection is labelled "Maungatua." In view of the fact that all the examples that I have seen have localities in the South Island, I consider the published type locality to be an error. 20 examples.

**Holcaspis mordax** Broun, 1886, *Man. New Zeal. Col.*, IV, p. 938.  
*Pterostichus humuensis* Broun, 1893, *Man. New Zeal. Col.*, V, p. 996  
(n.syn.).

*Pterostichus scitipennis* Broun, 1893, *loc. cit.*, p. 1396 (n.syn.).  
Figs. 31, 81.

Length: 11–13 mm.

Very similar to *Holcaspis sternalis*, differing in having the elytral intervals convex instead of flat, and only one setiferous puncture on the third interval, situated at about one third of the length of the elytra from the apex; striae faintly punctured towards the base.

Localities: Munua, near Papakura; Mount Pirongia, Waikato; Titirangi; foot of Mount Egmont. 8 examples.

**Holcaspis impiger** Broun, 1886, *Man. New Zeal. Col.*, IV, p. 879.  
*Pterostichus edax* Broun, 1893, *Man. New Zeal. Col.*, VI, p. 1326  
(n.syn.).

*Pterostichus sculpturalis* Broun, 1917, *Bull. New Zeal. Inst.*, I, p. 362 (n.syn.).

*Pterostichus fenwicki* Broun, 1921, *Bull. New Zeal. Inst.*, I, p. 599  
(n.syn.).

Figs. 32, 82.

Length: 12–15 mm.

The pronotum has a small impression outside the normal basal impression on each side; the elytral striae are not deeply impressed and are irregular, except the 3rd, which is straight until it approaches the apex. The striae are faintly but regularly punctured and the intervals are without setiferous punctures.

Localities: Flagstaff Mountain, near Dunedin; Mt. Maungatua; Dusky Bay, Otago; Mt. Dick, Lake Wakatipu; Te Oneroa; Hump Ridge, near Invercargill. 10 examples.

**Holcaspis algida** n.sp.

Figs. 33, 83.

Length: 10 mm. Colour: black, with the palpi, fore tarsi and antennae reddish.

Head similar to that of *H. angustula* Chaudoir, but with the eyes more prominent. Pronotum: ratio breadth to length 1.2. Median line evenly impressed, not reaching apex or base; with two basal impressions on each side, the outer one reaching the base; sides contracted basally but hardly sinuate; basal angles rectangular, sharp; two seta on each side, one before the middle and one at the hind angle. Elytra: basal margin and shoulder prominent, the latter toothed; parallel sided, only slightly sinuate near the apex; striae faint, punctured; intervals almost flat; no setiferous punctures on the intervals. Microsculpture well developed, isodiametric. ♂ without a tooth in the middle of the posterior edge of the hind femur. The blade of the aedeagus has a sharper angle than that in *H. angustula* Chaudoir and the dorsal paramere is hooked instead of being pointed.

Locality: Mount Algidus, Canterbury, 5 ♂♂, 2 ♀♀. Type in the British Museum.

**Holcaspis angustula** Chaudoir, 1865, *Bull. Soc. Nat. Mosc.*, XXXVIII, 3, p. 101; Broun, 1880, *Man. New Zeal. Col.*, I, p. 32.

*Omaseus elongata* Blanchard, 1853, *Voyage Pôle, Sud*, IV, p. 28, t. 2, f. 4 (non Duftschmidt).

*Holcaspis thoracicus* Broun, 1881, *Man. New Zeal. Col.*, II, p. 657 (n.syn.).

*Holcaspis placidus* Broun, 1881, *loc. cit.*, p. 658 (n.syn.).

*Pterostichus chalmersi* Broun, 1908, *Ann. Mag. Nat. Hist.* (8), II, p. 420 (n.syn.).

Figs. 34, 84.

Length: 12–15 mm. The pronotum has a small impression outside the normal basal fovea on each side; elytral striae regular, faintly punctured towards the base; intervals without setiferous punctures.

Localities: Akaroa; Moeraki; Port Chalmers; Dunedin; Taieri; Wedderburn. The type locality of *H. thoracicus* Broun like that of *H. sternalis* is given as Whangarei Harbour, but the unique example in the Broun Collection is labelled "Taieri," and as I have seen no example from the North Island, I conclude that the published locality is incorrect. 35 examples.

**Holcaspis longiformis** (Sharp, 1886), *Trans. R. Dublin Soc.* (2), III, p. 369 (*Pterostichus*); Broun, 1893, *Man. New Zeal. Col.*, V, p. 991.

*Pterostichus disparalis* Broun, 1893, *Man. New Zeal. Col.*, VI, p. 1324 (n.syn.).

Figs. 35, 85.

Length: 12 mm.

Very close to *H. angustula* and *H. algida*, but narrower and more parallel sided. The pronotum is slightly longer in proportion to its breadth; with only the slightest trace of punctures on the striae, towards the base. The male genitalia differ considerably, the blade of the aedeagus being rounded, without angles.

Localities: Christchurch; Moeraki. 9 examples.

**Holcaspis catenulata** Broun, 1882, *New Zeal. Journ. Sci.*, I, p. 222; *Man. New Zeal. Col.*, III, 1886, p. 753.

*Pterostichus insidiosus* Broun, 1893, *Man. New Zeal. Col.*, V, p. 999 (n.syn.).

*Pterostichus inconstans* Broun, 1893, *loc. cit.*, p. 999 (n.syn.).

*Pterostichus philpotti* Broun, 1908, *Ann. Mag. Nat. Hist.* (8), II, p. 418 (n.syn.).

Figs. 36, 86.

Length: 15–17 mm.

The pronotum is contracted towards the base; posterior angles very obtuse and rounded; the basal fovea on each side is a single almost circular impression; shoulders of the elytra not prominent; striae moderately straight, but in some examples very irregular, often united laterally; striae faintly punctured; intervals flat, or in larger examples slightly convex; 2 or 3 setiferous punctures on the 3rd interval; recurved margin of the elytra extremely narrow.

Localities: Taieri; Invercargill; Te Oneroa. 9 examples.

**Holcaspis brouniana** (Sharp, 1886), *Trans. R. Soc. Dublin* (2), III, p. 367 (*Pterostichus*); Broun, 1893, *Man. New Zeal. Col.*, V, p. 992.

Figs. 37, 87.

Length: 17-18 mm.

Similar to *Holcaspis catenulata*, but larger and with the pronotum more transverse; elytral striae faintly punctured; intervals slightly convex with a strong isodiametric microsculpture, and without setiferous punctures. The posterior femur in the ♂ has a strong tooth in the middle of the hind edge. The shoulders of the elytra are rounded and the basal margin is completely absent.

Localities: Picton; Clarence Bridge. 10 examples.

**Holcaspis elongella** (White, 1846), in Richardson and Gray, *Voyage of Erebus and Terror*, Ins., p. 4 (*Cophosus*); Chaudoir, 1865, *Bull. Soc. Nat. Mosc.*, XXXVIII, iii, p. 104; Broun, 1880, *Man. New Zeal. Col.*, I, p. 39; Sharp, 1884, *New Zeal. Journ. Sci.*, p. 298.

*Pterostichus constrictellus* Sharp, 1886, *Trans. R. Dublin Soc.* (2), III, p. 368; Broun, 1893, *Man. New Zeal. Col.*, V, p. 994 (n.syn.).

*Pterostichus detractus* Broun, 1893, *Man. New Zeal. Col.*, p. 996 (n.syn.).

Figs. 38, 88.

Length: 12-14 mm.

Differs from *H. brouniana* Sharp mainly in being much smaller and in the fact that the basal margin of the elytra is present. Sharp (l.c., p. 368) states that *H. elongella* has three lateral thoracic setae, but examination of the type discloses the presence of four setae on each side of the thorax, so that it does not differ from *P. constrictellus* Sharp and *P. detractus* Broun.

Localities: Picton; Canterbury; Lyttelton, Mount Grey, Christchurch, Dyer's Pass. 24 examples.

**Holcaspis egregialis** (Broun, 1917), *Bull. N.Z. Inst.*, I, p. 362 (*Pterostichus*).

Figs. 39, 89.

Length: 13 mm.

Pronotum with sides uniformly curved outwards from apex to base; basal foveae single, each side of pronotum with 4 setiferous punctures; raised margin and marginal groove of both pronotum and elytra extremely narrow, giving the body a very convex appearance. Elytra with shoulders dentate; basal margin well marked; striae marked only as rows of very faint punctures; intervals quite flat; two setiferous punctures in the apical half of the 3rd interval.

Locality: Staircase, 3,500 ft., at the south end of the Remarkables, east of Lake Wakatipu. A single ♂.

**Holcaspis hudsoni** n.sp.

Figs. 40, 90.

Length: 15–17 mm. Colour: aeneous-black.

Pronotum with sides moderately curved outwards, slightly sinuate in front of the posterior angles which are square; each side bearing 4 or 5 setiferous punctures; a small impression external to the normal basal fovea on each side; median line impressed not reaching apex or base. Elytra with basal margins well developed; shoulders not prominent, slightly dentate; striae faintly punctured, not deeply impressed and occasionally interrupted; intervals slightly convex, the 3rd with 3 or 4 setiferous punctures near the 3rd stria. Elytra rather sharply truncate behind the apical sinuation.

Localities: Hammer (Lewis), 2 ♂♂; Canterbury, 1 ♂ from the Broun Collection, labelled "*subaenea*." Type in the British Museum (Canterbury ex.).

**Holcaspis suteri** Broun, 1893, *Man. New Zeal. Col.*, VI, p. 1324.

Figs. 41, 91.

Length: 15–17 mm.

The sides of the pronotum have a long but slight sinuation in front of the posterior angles which are rectangular; each side bears 4 setiferous punctures; a double impression at the base on each side; elytral striae more strongly punctured towards the base; intervals slightly convex; the 3rd interval with 5 or 6 setiferous punctures.

Localities: Dyer's Pass, Port Hills, at 900 ft.; Mount Grey; Mount Robert, Canterbury, 3 ♂♂, 1 ♀.

**Holcaspis dentifera** (Broun, 1880), *Man. New Zeal. Col.*, I, p. 36 (*Trichosternus*).**Pterostichus eruensis** Hudson (Broun MS.), 1934, *New Zealand Beetles*, p. 37.

Figs. 42, 78, 92.

Length: 17–20 mm.

Pronotum with sides curved uniformly outwards from apex to base; basal foveae single, opening on to the base; each side of the pronotum with 5 setiferous punctures.

Elytra with intervals 3, 5 and 7 considerably wider and more convex than the others, uniting apically and enclosing intervals 4 and 6; striae unpunctured, or very faintly punctured; intervals without setiferous punctures; apical sinuation of the elytra very sharp. Isodiametric microsculpture strong, giving the elytra a matt surface. The middle of the hind edge of the posterior femur in the ♂ is bluntly pointed, but hardly dentate.

Localities: Parua, Whangarei Harbour; Maori Bush, Erua; Horopito; Ohakune; Egmont. 15 examples.

**Holcaspis odontella** (Broun, 1908), *Ann. Mag. Nat. Hist.* (8), II, p. 410 (*Pterostichus*).

Figs. 43, 93.

Length: 17 mm.

Sides of pronotum very convexly rounded, each bearing 4 setiferous punctures; not sinuate in front of the posterior angles, which

are pointed but very obtuse (ca.  $120^\circ$ ); basal impression linear, double. Elytra with shoulders rounded and basal margin obsolete; striae with obsolete punctures; intervals convex, but without setiferous punctures. Apical sinuation of elytra abrupt. All femora are greatly expanded, the anterior and posterior being bulbous beneath, but this appears to be merely an aberration, in view of the wrinkled and broken surface. The posterior tibiae have a tooth in the middle of the inner margin.

Locality: Near Mount Egmont, Taranaki. A single ♂.

**Holcaspis hispida** (Broun, 1876), *Trans. New Zeal. Inst.*, IX, p. 371 (*Trichosternus*).

*Holcaspis hispidulus* Broun, 1880, *Man. New Zeal. Col.*, I, p. 40.

*Holcaspis pellax* Broun, 1881, *op. cit.*, II, 1881, p. 656 (n.syn.).

*Holcaspis hybridus* Broun, 1886, *op. cit.*, IV, p. 826 (n.syn.).

*Pterostichus ithaginis* Broun, 1893, *Ann. Mag. Nat. Hist.*, (6), XII, p. 162 (n.syn.).

*Pterostichus obsoletus* Broun, 1893, *tom. cit.*, p. 163 (n.syn.).

*Pterostichus vexatus* Broun, 1908, *op. cit.*, (8), II, p. 417 (n.syn.).

Figs. 44, 94.

Length: 14–17 mm.

Pronotum with sides uniformly curved outwards from apex almost to the base where there is a slight sinuation; each side bearing 4 setiferous punctures; basal impressions single. Elytra with basal margins obsolete, as is the basal end of the first stria; striae irregularly punctured; intervals slightly convex, without setiferous punctures.

Localities: Kikiwai, Whangarei Heads; Auckland; Ligar's Bush, Papakura; Hunua Range; Tuakau, Waikato; Te Arohā; Wellington. 17 examples.

**Holcaspis oedienema** Bates, 1894, *Ann. Mag. Nat. Hist.* (4), XIII, p. 243.

*Holcaspis cribrate* Broun, 1882, *New Zeal. Journ. Sci.*, I, p. 222, *Man. New Zeal. Col.*, III, 1886, p. 752; G. V. Hudson, 1934, *New Zealand Beetles*, p. 37 (n.syn.).

*Pterostichus myrmidon* Sharp, 1886, *Trans. R. Dublin Soc.* (2), III, p. 368, pl. 12, f. 8; Broun, 1893, *Man. New Zeal. Col.*, V, p. 993 (n.syn.).

*Pterostichus rugifrons* Sharp, 1886, *Trans. R. Dublin Soc.* (2), III, p. 451; Broun, 1893, *Man. New Zeal. Col.*, VII, p. 1397 (n.syn.).

*Pterostichus pastoricius* Broun, 1893, *op. cit.*, V, p. 994 (n.syn.).

*Pterostichus egmontensis* Broun, 1893, *op. cit.*, V, p. 997 (n.syn.).

*Pterostichus irregularis* Broun, 1893, *op. cit.*, V, p. 998 (n.syn.).

*Pterostichus sculptipes* Broun, 1893, *op. cit.*, VI, p. 1325 (n.syn.).

*Pterostichus lewisi* Broun, 1894, *Ann. Mag. Nat. Hist.*, (6), XIV, p. 310; G. V. Hudson, 1934, *New Zeal. Beetles*, p. 37 (n.syn.).

*Pterostichus setiventris* Broun, 1903, *Ann. Mag. Nat. Hist.* (7), XI, p. 606 (n.syn.).

*Pterostichus antennalis* Broun, 1908, *Ann. Mag. Nat. Hist.* (8), II, p. 412 (n.syn.).

Figs. 45, 95.

Length: 15–22 mm.

I have seen more than 50 examples of this species, and it appears

to vary rather more than others of the genus, but I do not hesitate to establish the above synonymy on account of the identity of the male genitalia of all the types, and because there are no external characters which are sufficiently constant to allow of separation. The characters given by Broun for distinguishing the species can only be regarded as individual variations.

The sides of the pronotum are curved outwards from apex to base; the basal angles are rather greater than rectangles, and the points project slightly. The basal impression on each side is double. There are four setiferous punctures on each side of the pronotum.

The elytral intervals are slightly convex and without setiferous punctures. The striae are very variable, with the puncturation obsolete, so that the striae appear to be broken at irregular intervals.

Localities: Waikato; Napier; Mount Egmont; Mount Holdsworth, Tararua Range; Makara; Wellington; Takuratahi; Pelorus Sound; Picton; Mount Arthur; Wangapeka Valley; Glenhope; Boatman's, near Reefton; Westport; Greymouth; Ratapihipihi.

**Holcaspis mucronata** Broun, 1886, *Man. New Zeal. Col.*, p. 826.

*Pterostichus oxymelus* Broun, 1908, *Ann. Mag. Nat. Hist.* (8), II, p. 415 (n.syn.).

*Pterostichus burrowsi* Broun, 1914, *Bull. New Zeal. Inst.*, I, iii, p. 150 (n.syn.).

*Pterostichus fieldi* Broun, 1915, *Bull. New Zeal. Inst.*, I, iv, p. 276 (n.syn.).

Figs. 46, 96.

Length: 14–18 mm.

Pronotum strongly contracted basally; the sides sinuate above the posterior angles, which are rectangular; each side bearing 4 or 5 setiferous punctures; basal impressions broad, single, opening on to the base. Elytra with shoulders rounded; basal margin complete; striae faintly punctured; intervals slightly convex, without setiferous punctures. In the ♂ the inner side of the apex of the posterior tibia is produced into a long point.

Localities: Waitakerei Range, Auckland; Opotiki; Manawatu Gorge; Mount Hutt, Canterbury. 6 examples.

**Holcaspis delator** (Broun, 1893), *Man. New Zeal. Col.*, VII, p. 1397 (*Pterostichus*).

Figs. 47, 97.

Length: 16 mm.

Pronotum with sides very convexly rounded, contracted basally and sinuate in front of the posterior angles, which are rectangular; each side bearing 4 setiferous punctures; basal impressions small and shallow. Elytra with the basal margin extending in as far as the scutellar stria; striae with punctures almost obsolete, interrupted towards the apex; intervals slightly convex, without setiferous punctures.

Locality: Ashburton. A single ♂.

**Holcaspis subaenea** (Guérin, 1841), *Rev. Zool.*, p. 122; Bates, 1874, *Ann. Mag. Nat. Hist.* (4), XIII, p. 243; Broun, 1880, *Man. New Zeal. Col.*, I, p. 38.

*Pterostichus sinuellus* Broun, 1893, *Man. New Zeal. Col.*, VI, p. 1325 (n.syn.).

Figs. 2, 48, 98.

Length: 17–19 mm.

Pronotum strongly contracted towards the base; sides sinuate above the posterior angles, which are square; each side of the pronotum bearing 4 setiferous punctures. Elytra with rather faint striae, which are irregularly interrupted, but unpunctured; intervals slightly convex, without setiferous punctures.

Localities: Akaroa, Lyttelton, Canterbury. 5 examples.

The type of this species is lost, but Dr R. Jeannel has kindly sent me a specimen of a series of four taken at Akaroa by Arnoux and Latour, and received by the Paris Museum in 1847. Dr Jeannel writes that these specimens were probably seen by Guérin-Ménéville and that the identification was confirmed by Tschitscherin.

**Holcaspis vagepunctata** (White, 1846) in Richardson and Gray, *Voy. Erebus and Terror*, Ins., p. 4; Guérin, 1847, *Rev. Zool.*, p. 89; Bates, 1874, *Ann. Mag. Nat. Hist.* (4), XIII, p. 243.

*Holcaspis intermittens* Chaudoir, 1865, *Bull. Soc. Nat. Mosc.*, XXXVIII, iii, p. 103 (n.syn.).

*Holcaspis praecox* Broun, 1886, *Man. New Zeal. Col.*, IV, p. 827; G.V. Hudson, 1934, *New Zealand Beetles*, p. 37 (n.syn.).

Figs. 49, 99.

Length: 15–16 mm.

This species was synonymised with *H. subaenea* Guér. by Bates, but examination of the type reveals no justification for this.

Pronotum transverse; strongly contracted towards the base, the sides shortly sinuate in front of the post angles, which are square; 3 or 4 setiferous punctures in the marginal groove on each side. Elytral striae obscurely punctured; intervals moderately convex, without setiferous punctures.

Localities: Port Nicholson; Wellington. 20 examples.

**Holcaspis sinuiventris** (Broun, 1908), *Ann. Mag. Nat. Hist.* (8) II, p. 416 (*Pterostichus*).

Figs. 50, 100.

Length: 14 mm.

Pronotum with sides strongly recurved above posterior angles so that the latter are acute and projecting; each side bearing 4 setiferous punctures; basal impression on each side broad, opening on to base. Elytra with the striae well impressed; more strongly punctured towards the base; intervals moderately convex and without setiferous punctures; apical sinuation of the elytra strong.

Locality: Manawatu Flats, 9 miles below the gorge. A single ♂.

Genus *PLOCAMOSTETHUS* nov.Genotype: *Plocamostethus planiusculus* (White, 1846).

Without setiferous punctures on the 3rd and 7th elytral interval; basal segment of the antenna normal, not flattened above; dorsal surface of all tarsal segments smooth; mentum without pits; a group of long setae on the extremity of the prosternum; the setiferous punctures of the marginal series of the elytra numerous, closely and regularly spaced; hindwings absent and elytra joined along the sutural margins.

***Plocamostethus planiusculus*** (White, 1846), in Richardson and Gray, *Voy. Erebus and Terror*, Ins., p. 3, pl. 1, f. 7 (*Feronia*); Guérin, 1847, *Rev. Zool.*, p. 87; Chaudoir, 1865, *Bull. Soc. Nat. Mosc.*, XXXVIII, 3, p. 75; Broun, 1880, *Man. New Zeal. Col.* I, p. 36 (*Trichosternus*).

Figs. 51, 101.

Length: 25–29 mm. Colour: black.

Mandibles unusually prominent, as long as the head, curved near the tips and sharply pointed; eyes small but convex. Pronotum quadrate, slightly contracted towards the base; sides slightly sinuate in front of the posterior angles, which are rectangular or slightly obtuse. Elytra ovoid, shoulders dentate; striae well marked, finely and closely punctured; intervals quite flat on the disc, convex near the apex, without setiferous punctures; marginal series of setiferous punctures very numerous and not broken into groups.

Localities: New Plymouth; Wellington; Picton; Mount Arthur; Boatman's, Reefton; Clarence Bridge. 58 examples.

***Plocamostethus planiusculus* ssp. *latus* nov.**

Length: 25–29 mm.

This subspecies differs from the typical form in having the pronotum less contracted at the base, more parallel-sided.

Ratio greatest width of pronotum/length of pronotum for *P. planiusculus planiusculus* (average of 5 ex.) = 1.31. For ssp. *latus* (average of 4 ex.) = 1.35. Ratio width of base of pronotum/length of pronotum for *P. planiusculus planiusculus* (average of 5 ex.) = 1.09. For ssp. *latus* (average of 4 ex.) = 1.23.

The elytral intervals are flat on the disc, convex towards sides and apex, but distinctly less so than in the typical form. The aedeagus is scarcely distinguishable from that of *P. planiusculus planiusculus*.

Locality: Pōkororo, near Mount Arthur, Nelson Province (E. S. Gourlay, 13.xii.1927), 2 ♂♂, 2 ♀♀. Holotype ♂ and paratype ♀ in the Cawthron Institute, Nelson, New Zealand. Allotype ♀ and paratype ♂ in the British Museum.

***Plocamostethus planiusculus* ssp. *durvillei* nov.**

Length: 18–21 mm.

The examples taken by Mr. E. S. Gourlay on D'Urville Island are remarkable for their uniformly small size, but they appear to be identical in all other respects with the typical form. Ratio greatest

width/length of pronotum (average for 5 examples selected at random) = 1.31. Ratio width of base/length of pronotum (average for the same five examples) = 1.03.

These ratios show the pronotum to be of the same shape as in the typical form. The aedeagus is identical in shape in the two forms. The separation of a subspecies, nevertheless, is justified by the discontinuity in size and a certain degree of geographical isolation.

Locality: D'Urville Island, Nelson Province (E. S. Gourlay, 13-17.i.1931). 4♂♂, 9♀♀. Holotype ♂ and paratypes in the Cawthron Institute, Nelson, New Zealand. Allotype and paratypes in the British Museum.

#### Genus NEOFERONIA nov.

Genotype: *Neoferonia procerula* (Broun, 1886).

Elytral intervals without setiferous punctures, basal segments of the antennae normal, rounded; the pronotum with two setae on each side, the tarsi normal, not grooved; the mentum plane, without a pit on each side; hindwings absent and the elytra soldered together along the suture.

#### KEY TO THE SPECIES.

1. Posterior angles of the pronotum obtuse ( $>90^\circ$ ). . . 2  
     Posterior angles of the pronotum square or even acute. . . . . 3
2. (1) Intervals quite flat, even at the apex; posterior angles of the pronotum blunt; sides hardly sinuate. *straneoi* n.sp.  
     Intervals moderately convex, more so at the apex; posterior angles of the pronotum sharp; sides { *integrata* (Bates)  
     sinuate. . . . . { *prolixa* (Broun)
3. (1) Intervals quite flat, even at the apex; sides of the pronotum not sinuate in front of the posterior angles. . . . . *procerula* (Broun)  
     Intervals convex, sides of pronotum distinctly sinuate. . . . . 4
4. (3) Pronotum with the width at the base equal to the width at the apex; posterior angles curved out, acute (fig. 103). . . . . *ardua* (Broun)  
     Pronotum at the base considerably wider than at the apex (fig. 106). . . . . *fossalis* (Broun)

#### *Neoferonia straneoi* n.sp.

Fig. 102.

Length: 18 mm. Colour: black.

Head broad with hemispherical eyes. Pronotum transverse, ratio width/length =  $4/3$ ; median line impressed, not reaching apex or base; strongly contracted towards base so that width of apex = width of base; sides not sinuate above the posterior angles, which are obtuse and rather blunt; basal impressions rather broad. Elytra with shoulders rounded, slightly dentate; striae faint, not impressed, finely and closely punctured; intervals flat; marginal series of setiferous punctures numbering 18.

Exact locality in New Zealand unknown.

Holotype ♂ in the collection of Dr S. L. Straneo, Parma; allotype in the British Museum.

**Neoferonia ardua** (Broun, 1893), *Man. New Zeal. Col.*, VI. p. 1395 (*Holcaspis*); G. V. Hudson, 1934, *New Zealand Beetles*, p. 36 (*Pterostichus*).

*Pterostichus truncatulus* (Broun, 1923), *Bull. New Zeal. Inst.*, I, viii, p. 674 (n.syn.).

Figs. 52, 103.

Length: 21 mm. Colour: black.

Pronotum with the sides contracted towards the base and sinuate just in front of the posterior angles which project; median line impressed, reaching both apex and base. Elytra with a blunt tooth at each shoulder; striae well impressed, very faintly punctured; intervals slightly convex; distinctly convex at the apex; marginal series of setiferous punctures numbering 16; sides rather sharply truncate behind the apical sinuation.

Localities: Flora River, Mount Arthur, 2800 ft. (G. V. Hudson); Mount Owen, Nelson. 1 ♂, 3 ♀♀.

**Neoferonia integrata** (Bates, 1878), *Ent. Mo. Mag.* XV, p. 27 (*Holcaspis*); Broun, 1880, *Man. New Zeal. Col.*, I, p. 40.

*Steropus helmsi* Sharp, 1883, *Ent. Mo. Mag.*, XX, p. 25; Broun, 1893, *Man. New Zeal. Col.*, V, p. 989 (n.syn.).

*Feronia convexidorsis* Tschitscherin, 1890, *Horae Soc. Ent. Ross.*, XXV, p. 166 (n.syn.).

I have not seen the type of *F. convexidorsis*, but from the description there can be no doubt of its identity.

*Pterostichus cavelli* Broun, 1893, *Man. New Zeal. Col.*, V, p. 991 (n.syn.).

*Pterostichus prasignis* Broun, 1903, *Ann. Mag. Nat. Hist.* (7), XI, p. 606 (n.syn.).

Figs. 53, 104.

Length: 18–21 mm. Colour: aeneous or black.

Pronotum with sides strongly convex outwardly; sinuate just before the posterior angles, which are sharp, rectangular or slightly obtuse; two deep impressions, on each side near the base, communicate with each other and open on to the base near the posterior angle. Elytra ovoid and tapering apically, rather pointed; striae regular and well impressed, very faintly punctured; intervals moderately convex, becoming more strongly so towards the apex.

Localities: Hokitika and Lake Paroa; Greymouth; Boatman's, near Reefton; Westport; Capleston, Westland; Kumara. 33 examples.

**Neoferonia prolixa** (Broun, 1880), *Man. New Zeal. Col.*, I, p. 35 (*Pterostichus*).

Figs. 54, 105.

Length: 18.5 mm. Colour: aeneous-black.

Very similar to *N. integrata* Bates, but more slender. In a specimen of *N. integrata* Bates, 18.5 mm. long, the width of thorax

and elytra respectively are 4.75 mm. and 6.0 mm., whereas in an example of *N. prolixa* Broun of the same length, they measure 4.0 mm. and 5.0 mm. The difference between the male genitalia of the two species is marked (see figs. 53 and 54) and allows of no confusion.

Locality: Martin's Bay, west coast of Otago. Known only from a single ♂.

*Neoferonia fossalis* (Broun, 1914), *Bull. New Zeal. Inst.*, I, iii, p. 149 (*Pterostichus*).

Fig. 106.

Length: 20.5 mm. Colour: metallic aeneous and bluish-black.

Pronotum with a long but slight sinuation on each side above the posterior angle, which is square; two shallow separate depressions near the base on each side, the outer one reaching the base; width of pronotum at the widest part 6 mm.; width of the elytra 7 mm. Elytral striae strongly impressed; faintly but regularly punctured. Intervals convex.

Locality: Hump Ridge, Invercargill. Known from a single ♀.

*Neoferonia procerula* (Broun, 1886), *Man. New Zeal. Col.*, IV, p. 827 (*Pterostichus*).

Figs. 55, 107.

Length: 19–21 mm. Colour: aeneous-black.

Pronotum with sides only moderately curved and hardly sinuate above the posterior angles, which are square; basal impressions double, shallow. Elytral striae regular, well impressed and faintly but regularly punctured. Intervals flat or slightly convex.

Localities: Mount Maungatua; Mount Dick; Port Chalmers. 5 ♂ ♂, 2 ♀ ♀.

Genus *RHYTISTERNUS* Chaudoir, 1865.

*Bull. Soc. Nat. Mosc.*, 38, III, p. 106.

Genotype: *Rhytisternus liopleurus* Chaudoir (here designated).

*Rhytisternus miser* Chaudoir, 1865, *Bull. Soc. Nat. Mosc.*, XXXVIII, 3, p. 108; 1874, *Ann. Mus. Civ. Genova*, VI, p. 598; Sloane, 1920, *Proc. Linn. Soc. N.S. Wales*, XLV, p. 164.

*Rhytisternus rugifrons* (Broun, 1880), *Man. New Zeal. Col.*, I, p. 41 (*Holcaspis*) (n.syn.).

The chitin of the head and prothorax of the type of *R. rugifrons* was evidently crumpled when soft.

*Rhytisternus erythrognaethus* Broun, 1893, *Man. New Zeal. Col.*, V, p. 986 (n.syn.).

I have not seen the type of this species. It is not to be found in the Broun collection. As no species of this genus, other than *R. miser*, appears in any of the material I have seen, and this species is obviously a recent introduction, it seems highly probable that it

is the only New Zealand species. The description given by Broun fits *R. miser* very well, except that he says "there is apparently only one seta on each side of the thorax." The posterior setiferous puncture is, in any case, difficult to see. I therefore have no hesitation in establishing the synonymy.

Length: 10–11 mm. Colour: black; mouthparts, antennae and tarsi reddish-brown.

The elytral striae are well impressed except for the basal halves of the sixth and seventh striae, which are very faint; striae without any trace of punctuation; intervals slightly convex, without setiferous punctures.

Localities: Auckland; Howick; Huia; Waitakerei; Mt. Albert; Tairua. 10 examples.

Known also from Queensland and Tasmania.

Genus *PSEGMATOPTERUS* Chaudoir, 1878.

Genotype: *Psegmatopterus politissimum* (White).

*Psegmatopterus politissimum* (White, 1846), in Richardson and Gray, *Voy. of Erebus and Terror*, Ins., p. 4 (*Platysma*); Broun, 1880, *Man. New Zeal. Col.*, I, 1880, p. 41 (*Holcaspis*).

*Psegmatopterus anchomenoides* Chaudoir, 1878, *Bull. Soc. Nat. Mosc.*, LIII, ii, p. 57 (n.syn.).

*Anchomenus hallianus* Broun, 1921, *Bull. New Zeal. Inst.*, I, vii, p. 598 (n.syn.).

Figs. 4, 56.

Length: 13–15 mm. Colour: black.

Pronotum with sides strongly sinuate above the posterior angles, which are rectangular; the raised margin of the sides of the pronotum is continued along the basal edge; elytral intervals strongly convex; striae very faintly punctured; elytra free; hindwings reduced, not folded, length slightly more than half that of the elytra.

Localities: Manawatu; Port Nicholson; Wellington; Rotoiti, Nelson. 8 examples.

*Psegmatopterus* appears to be closely related to *Chlaenioidius*, which includes four species, restricted to Australia, Tasmania, and New Caledonia. *Psegmatopterus* differs from *Chlaenioidius* in having the elytral intervals convex instead of flat, and in the pronotum, the sides of which are sinuate and constricted basally instead of being trapezoidal in form. The male genitalia in the two genera are similar in form, the aedeagus being in the form of a tube open only at the apex, while the two parameres are long and pointed.

Genus **LAEMOSTENUS** Schaufuss (Bonelli *in litt.*).

*Laemostenus* Schaufuss, 1864, Sitzungsber. Ges. Isis, Dresden, p. 121; Andrewes, *Trans. Ent. Soc. Lond.*, 1919, p. 91.

Genotype: *L. venustus* Clairville, 1806, *Ent. Helv.*, II, p. 87; Jeannel, *Rev. Francaise d'Ent.*, IV, 2. 1937, p. 84.

***Laemostenus complanatus*** (Dejean, 1828), *Spec. gén. Col.*, III, p. 58.

*Pristonychus terricola* Herbst. (of Hudson), 1934, *New Zealand Beetles*, p. 174.

Length: 13–15 mm. Colour: head, pronotum, legs and antennae dark brown; elytra bluish-black; basal and lateral margins and scutellum brown.

Pronotum quadrate, the sides with a slight, elongate sinuation in front of the posterior angles, which are obtuse; basal depressions shallow, obscurely punctured. Elytra with intervals slightly convex anteriorly, flat towards apex; striae well marked, faintly but regularly punctured. Microsculpture of the surface very strong, so that elytra have a matt appearance.

Localities: Tairua; Albert Park; Rangiriri; Wellington; Christchurch. 26 examples.

This species, of European or N. African origin, is cosmopolitan, having been carried about by shipping.

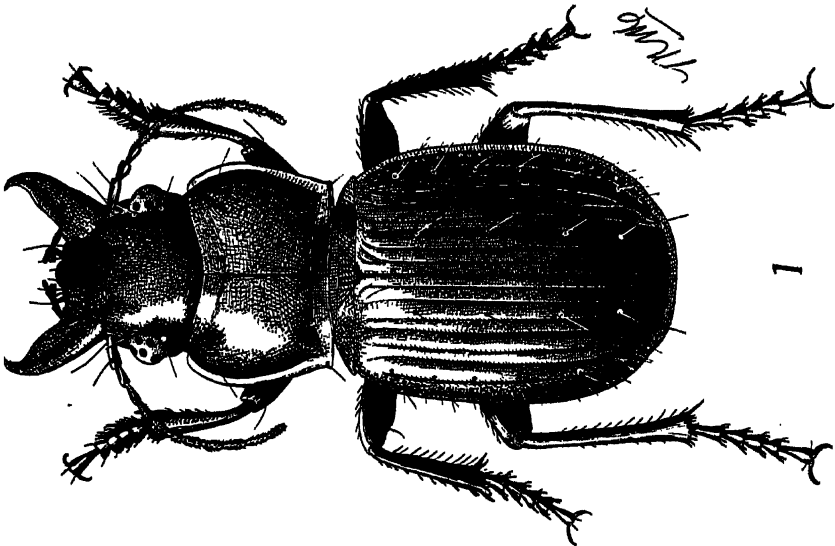


FIG. 1.—*Megadromus antarcticus* Claudoir ♂.

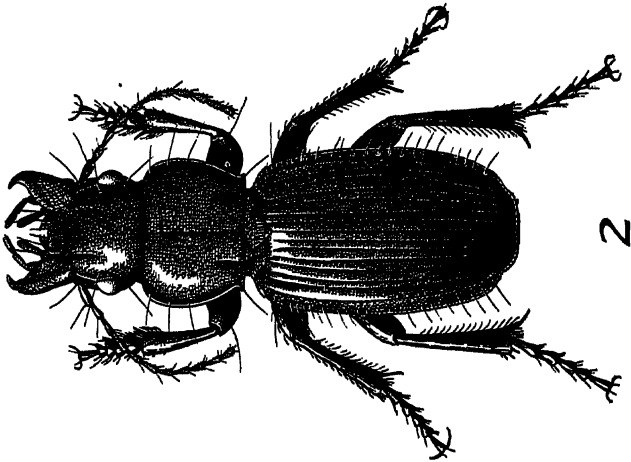


FIG. 2.—*Holcaspis subaeneu* (Guerin) ♂.



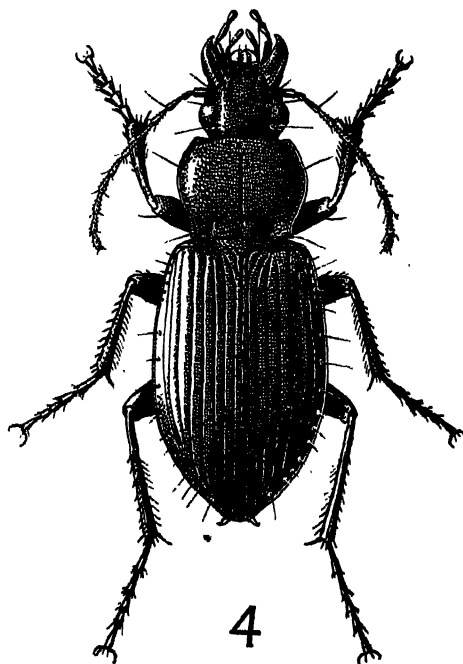
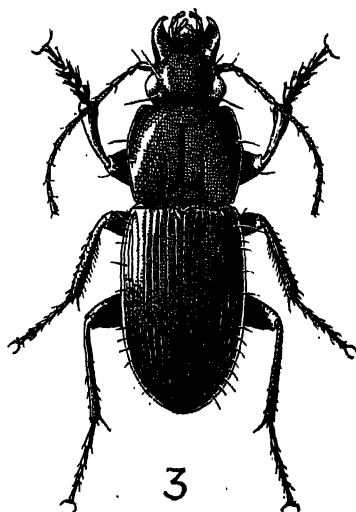


FIG 3.—*Aulacopodus calathoides* (Broun) ♂.

FIG. 4.—*Psephenopterus politissimus* (White) ♀.



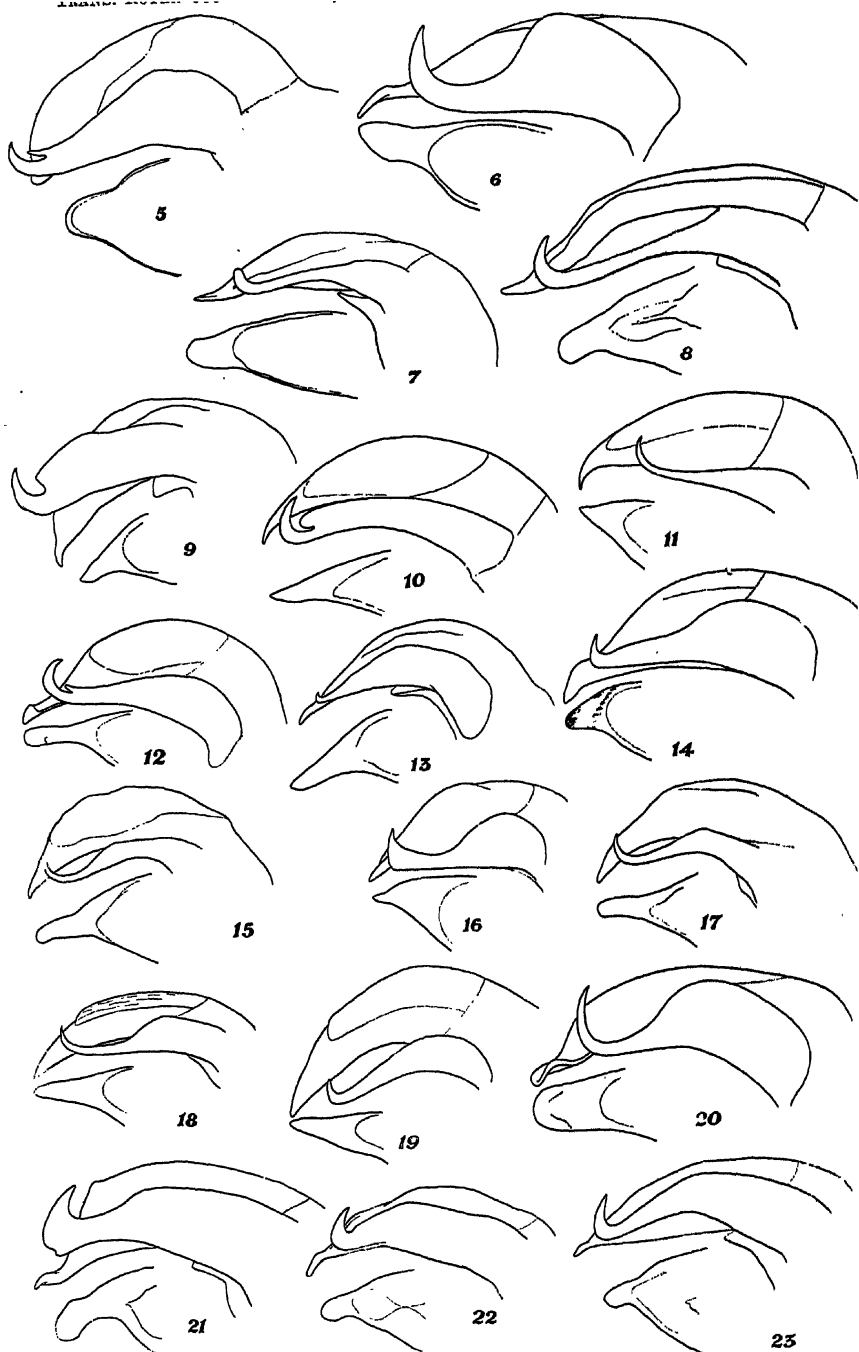


FIG. 5.—*Megadromus vigil* (White). FIG. 6.—*Megadromus lobipes* (Bates). FIG. 7.—*Megadromus turgidiceps* (Broun). FIG. 8.—*Megadromus bullatus* (Broun). FIG. 9.—*Megadromus australasiae* (Guerin). FIG. 10.—*Megadromus antarcticus* (Chaudoir). FIG. 11.—*Megadromus virens* (Broun). FIG. 12.—*Megadromus enysi* (Broun). FIG. 13.—*Megadromus capito* (White). FIG. 14.—*Megadromus temukensis* (Bates). FIG. 15.—*Megadromus rectalis* (Broun). FIG. 16.—*Megadromus alternus* (Broun). FIG. 17.—*Megadromus compressus* (Sharp). FIG. 18.—*Megadromus hammonensis* (Broun). FIG. 19.—*Megadromus rectangularis* (Chaudoir). FIG. 20.—*Megadromus hantoni* (Broun). FIG. 21.—*Megadromus sandaer* (Broun). FIG. 22.—*Megadromus*



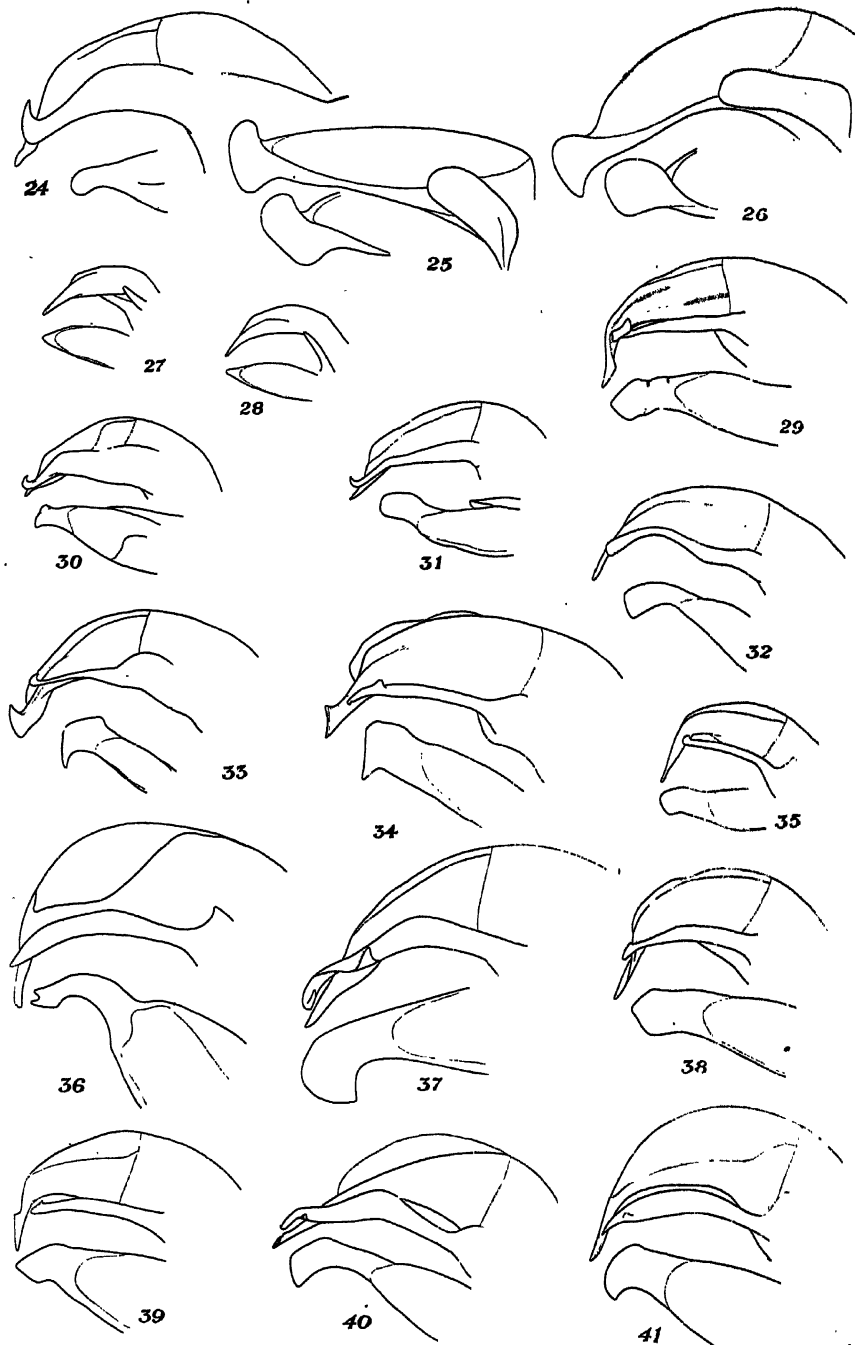


FIG. 24.—*Megadromus meritus* (Broun). FIG. 25.—*Zeopocetus calcaratus* Sharp.  
 FIG. 26.—*Zeopocetus putus* (Broun). FIG. 27.—*Aulacopodus sharpius* (Broun).  
 FIG. 28.—*Aulacopodus browni* (Cslki). FIG. 29.—*Holcaspis ovatella* Chaudoir. FIG. 30.—*Holcaspis sternalis* Broun. FIG. 31.—*Holcaspis mordax* Broun. FIG. 32.—*Holcaspis impiger* Broun. FIG. 33.—*Holcaspis algida* n.sp. FIG. 34.—*Holcaspis longiformis* (Sharp). FIG. 35.—*Holcaspis angustula* (Broun). FIG. 36.—*Holcaspis browniana* (Sharp). FIG. 37.—*Holcaspis catenulata* (White). FIG. 38.—*Holcaspis egregialis* (Broun). FIG. 39.—*Holcaspis elongella*  
 FIG. 40.—*Holcaspis* FIG. 41.—*Holcaspis*



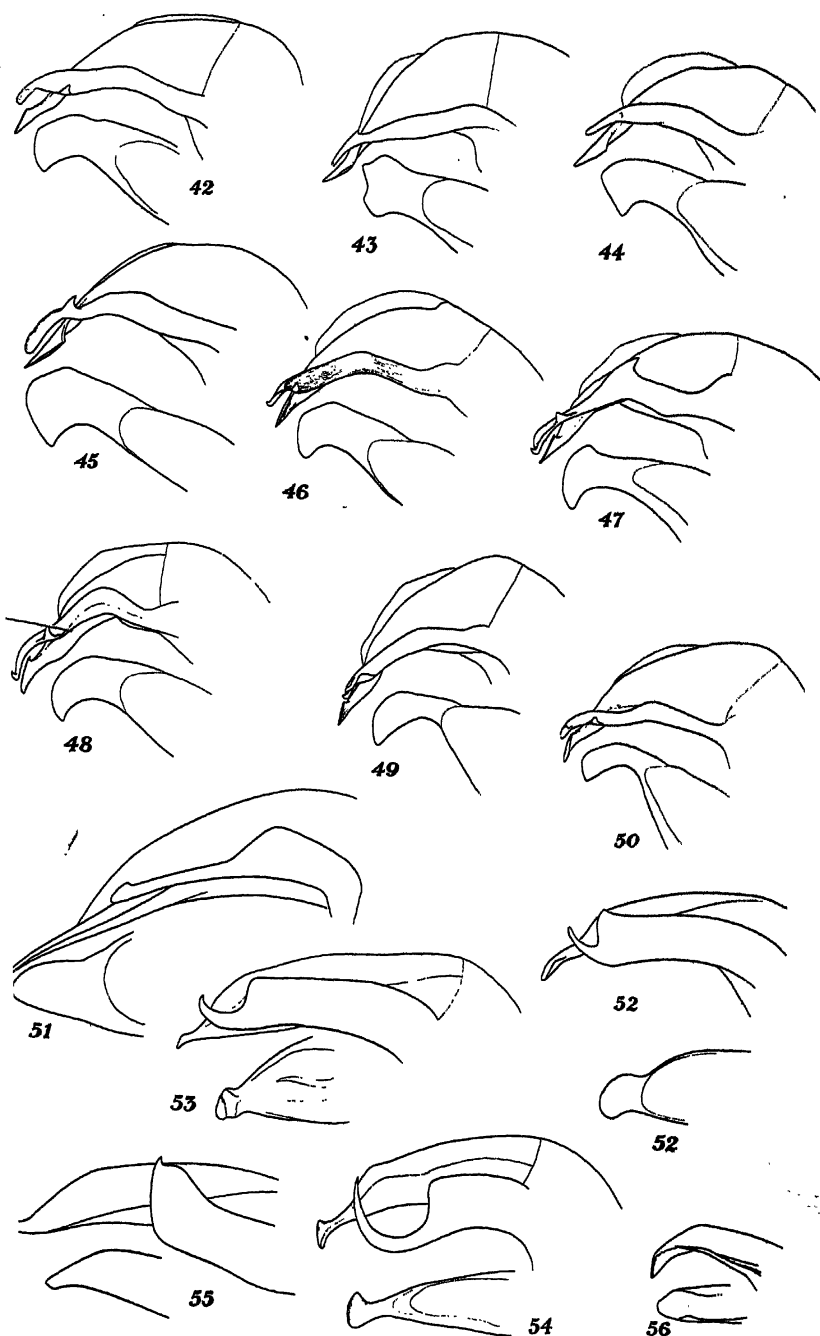


FIG. 42.—*Holocaspis dentifera* (Broun). FIG. 43.—*Holocaspis odontella* (Broun).  
 FIG. 44.—*Holocaspis hispida* (Broun). FIG. 45.—*Holocaspis oedipema* Bates.  
 FIG. 46.—*Holocaspis mucronata* Broun. FIG. 47.—*Holocaspis delator* (Broun).  
 FIG. 48.—*Holocaspis subaenea* (Guerin). FIG. 49.—*Holocaspis vagapunctata* (White).  
 FIG. 50.—*Holocaspis sinuiventris* (Broun). FIG. 51.—*Plocaamastix plumisculus*  
 (White). FIG. 52.—*Neoferonia ardua* (Broun). FIG. 53.—*Neoferonia integrata*  
 (Bates). FIG. 54.—*Neoferonia proliza* (Broun). FIG. 55.—*Neoferonia* sp.  
 FIG. 56.—*Neoferonia* sp.



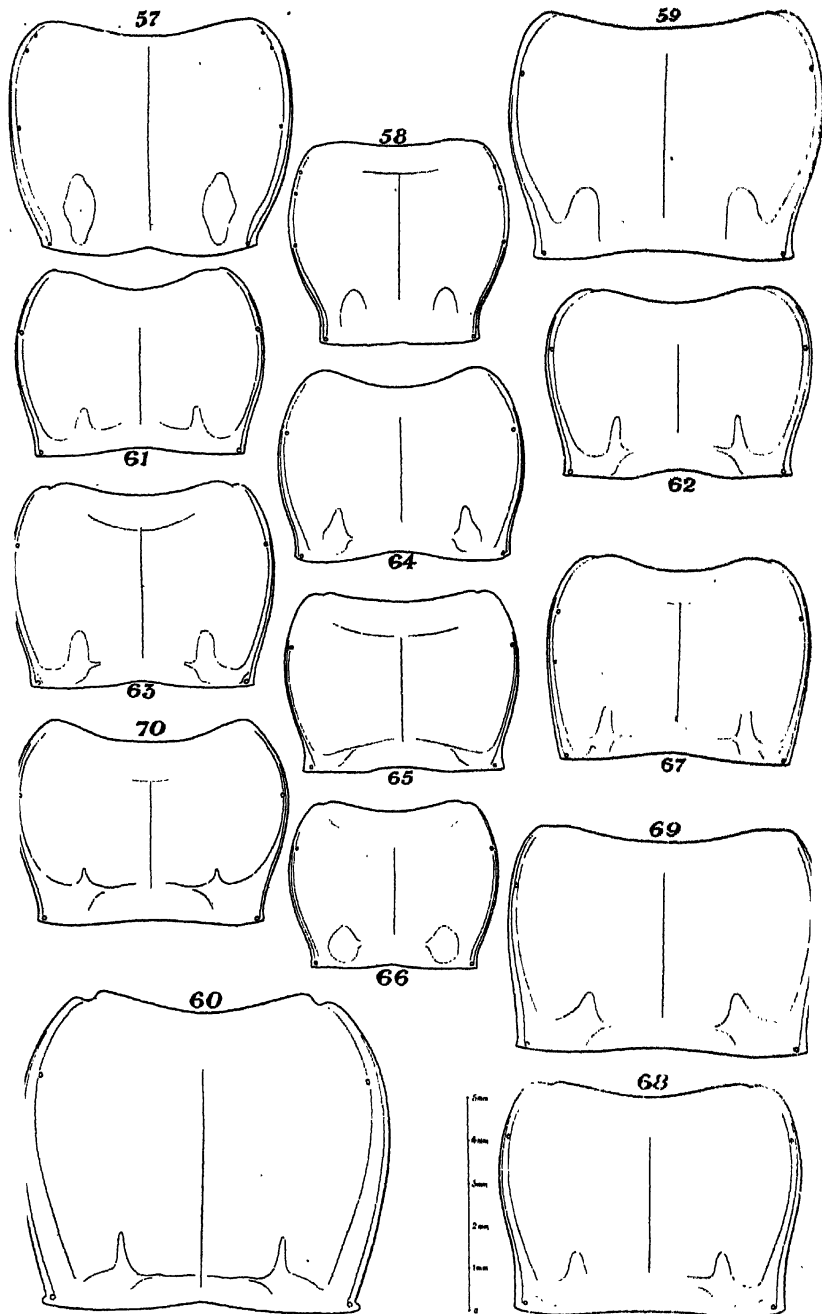


FIG. 57.—*Megadromus vigil* (White). FIG. 58.—*Megadromus turgidiceps* (Broun).  
FIG. 59.—*Megadromus australasiae* (Guerin). FIG. 60.—*Megadromus antarcticus*  
(Chaudoir). FIG. 61.—*Megadromus virens* (Broun). FIG. 62.—*Megadromus enyal*  
(Bates). FIG. 63.—*Megadromus capito* (White). FIG. 64.—*Megadromus temukensis*  
(Broun). FIG. 65.—*Megadromus rectalis* (Broun). FIG. 66.—*Megadromus compressus* (Sharp).  
FIG. 67.—*Megadromus alternus* (Broun). FIG. 68.—*Megadromus haplopus* (Broun).  
FIG. 69.—*Megadromus rectangularis* (Chaudoir). FIG. 70.—*Megadromus* (unlabeled).



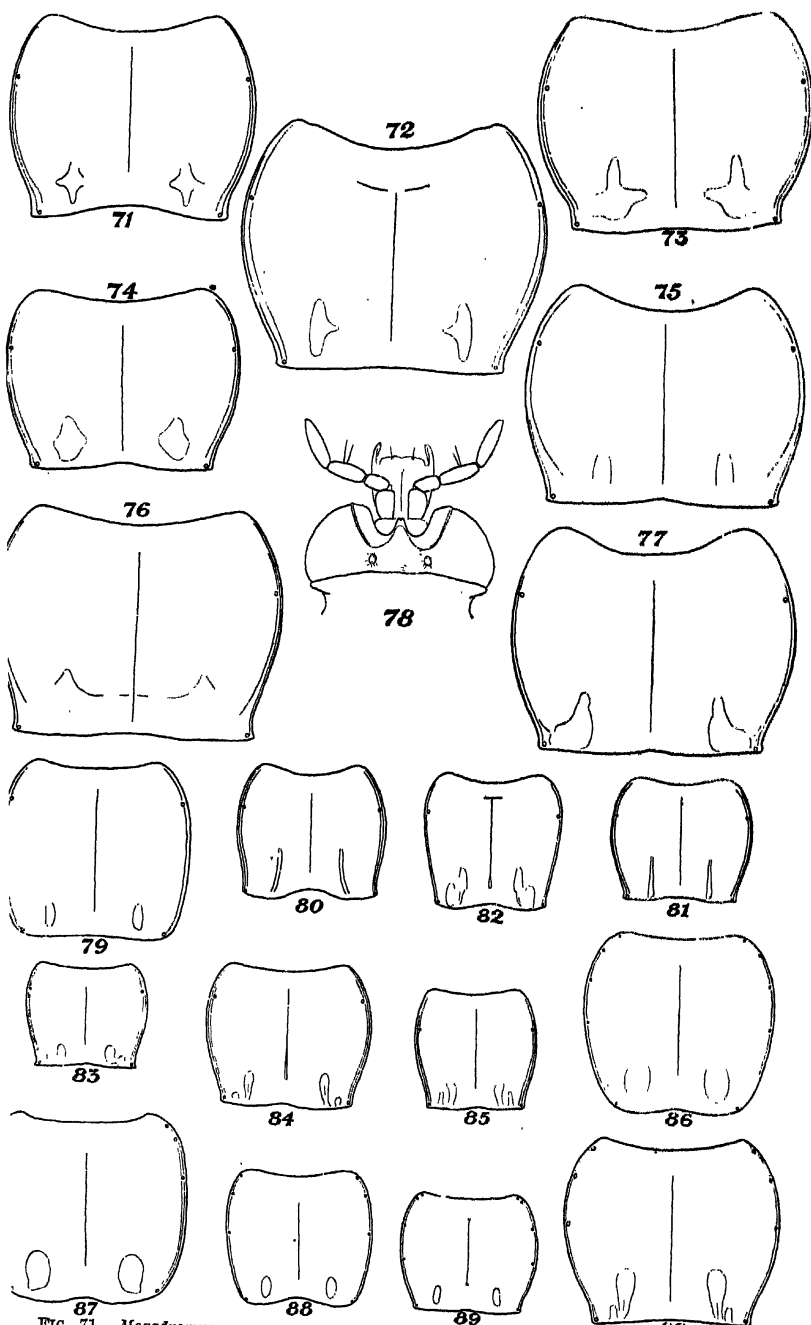
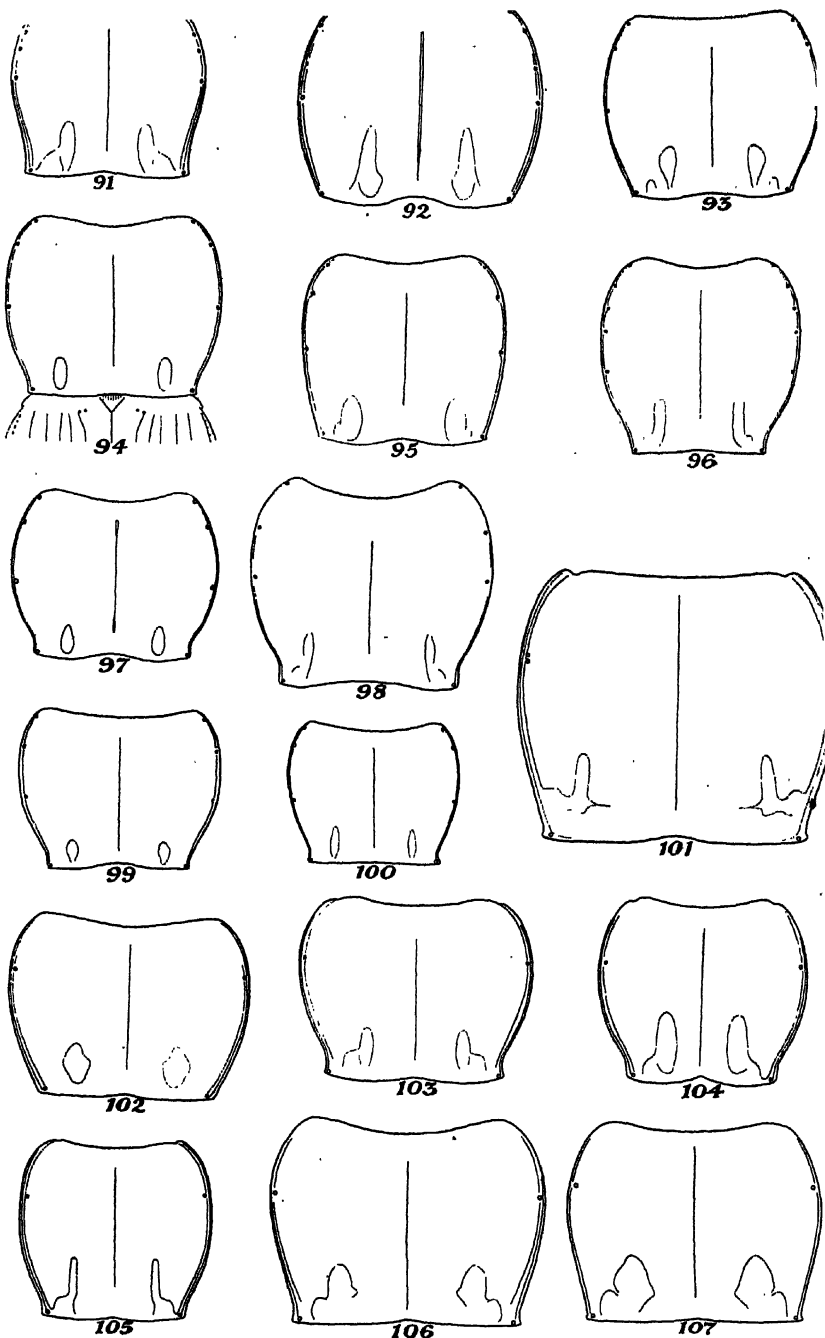


FIG. 71.—*Megadromus vagans* (Broun).  
 FIG. 72.—*Megadromus sandageri* (Broun).  
 FIG. 73.—*Megadromus memes* (Broun).  
 FIG. 74.—*Megadromus optabilis* (Broun).  
 FIG. 75.—*Megadromus fultonii* (Broun).  
 FIG. 76.—*Megadromus meritus* (Broun).  
 FIG. 77.—*Zoopocelus putus* (Broun).  
 FIG. 78.—*Holcaspis dentifera* (Broun).

FIG. 81.—*Holcaspis mordax* Broun.  
 FIG. 82.—*Holcaspis impiger* Broun.  
 FIG. 83.—*Holcaspis albidula* n.sp.  
 FIG. 84.—*Holcaspis angustula* Chaudohr.  
 FIG. 85.—*Holcaspis longiformis* (Sharp).  
 FIG. 86.—*Holcaspis eutryphala* (Broun).  
 FIG. 87.—*Holcaspis browniana* (Sharp).  
 FIG. 88.—*Holcaspis* sp.





- FIG. 91.—*Holcaspis suteri* (Broun).  
 FIG. 92.—*Holcaspis dentifera* (Broun).  
 FIG. 93.—*Holcaspis odontella* (Broun).  
 FIG. 94.—*Holcaspis hispidula* (Broun).  
 FIG. 95.—*Holcaspis oedionema* Bates.  
 FIG. 96.—*Holcaspis macronata* Broun.  
 FIG. 97.—*Holcaspis delator* (Broun).  
 FIG. 98.—*Holcaspis subaenea* (Guerin).  
 FIG. 99.—*Holcaspis vagepunctata* (White).  
 FIG. 100.—*Holcaspis sinuiventris* (Broun).  
 FIG. 101.—*Plocamioctethus planiusculus* (White).  
 FIG. 102.—*Neoferonia straneoi* n.sp.  
 FIG. 103.—*Neoferonia ardua* (Broun).  
 FIG. 104.—*Neoferonia integrata* (Bates).  
 FIG. 105.—*Neoferonia prolixa* (Broun).  
 FIG. 106.—*Neoferonia fossalis* (Broun).  
 FIG. 107.—*Neoferonia procerula* (Broun).



## APPENDIX.

## LIST OF AWARDS.

## AWARD OF THE HECTOR MEMORIAL MEDAL AND PRIZE.

1912. L. Cockayne, C.M.G., Ph.D., F.R.S., F.L.S., F.R.S.N.Z.—For researches in New Zealand botany.
1913. T. H. Easterfield, M.A., Ph.D., F.R.S.N.Z.—For researches in chemistry.
1914. E. Best, F.R.S.N.Z.—For researches in New Zealand ethnology.
1915. P. Marshall, M.A., D.Sc., F.G.S., F.R.S.N.Z.—For researches in New Zealand geology.
1916. Lord Rutherford of Nelson, O.M., D.Sc., F.R.S., F.R.S.N.Z.—For researches in physics.
1917. C. Chilton, M.A., D.Sc., M.B., C.M., F.L.S., F.R.S.N.Z.—For researches in zoology.
1918. T. F. Cheeseman, F.L.S., F.Z.S., F.R.S.N.Z.—For researches in New Zealand systematic botany.
1919. P. W. Robertson, M.A., M.Sc., Ph.D.—For researches in chemistry.
1920. S. Percy Smith, F.R.G.S., F.R.S.N.Z.—For researches in New Zealand ethnology.
1921. R. Speight, M.A., M.Sc., F.G.S., F.R.S.N.Z.—For work in New Zealand geology.
1922. C. Coleridge Farr, D.Sc., F.R.S., F.R.S.N.Z.—For research in physical science and more particularly work in connection with the magnetic survey of New Zealand.
1923. G. V. Hudson, F.E.S., F.R.S.N.Z.—For researches in New Zealand entomology.
1924. D. Petrie, M.A., F.R.S.N.Z.—For researches in New Zealand botany.
1925. B. C. Aston, F.I.C., F.R.S.N.Z.—For the investigation of New Zealand chemical problems.
1926. H. D. Skinner, M.A., F.R.S.N.Z.—For research in ethnology.
1927. C. A. Cotton, D.Sc., F.G.S., F.R.S.N.Z.—For researches in the geomorphology of New Zealand.
1928. D. M. Y. Sommerville, M.A., D.Sc., F.R.S.N.Z.—For his general mathematical work and particularly for his investigations in non-Euclidean geometry.
1929. G. M. Thomson, F.L.S., F.R.S.N.Z.—For researches on the acclimatisation of animals in New Zealand and on the natural history of New Zealand fishes.
1930. J. E. Holloway, L.Th., D.Sc., F.R.S., F.R.S.N.Z.—For researches in the life-histories of New Zealand *Pteridophytes*.

1931. W. P. Evans, M.A., Ph.D., F.R.S.N.Z.—For research in pure and applied chemistry.

1932. Te Rangi Hiroa (P. H. Buck), M.D., Ch.B (N.Z.), F.R.S.N.Z.—For researches in Maori ethnology.

1933. W. N. Benson, B.A., D.Sc., F.G.S., F.R.S.N.Z., and J. Marwick, M.A., D.Sc., F.R.S.N.Z.—For researches in New Zealand geology.

1934. G. E. Weatherburn, M.A., D.Sc.—For outstanding original work in mathematics, especially in the use of vector analysis.

1935. W. B. Benham, M.A., D.Sc., K.B.E., F.R.S., F.R.S.N.Z.—For original researches in New Zealand zoology.

1936. W. R. B. Oliver, D.Sc., F.L.S., F.Z.S., F.R.S.N.Z.—For research in New Zealand botany.

1937. J. R. Hosking, B.Sc., Ph.D.—For research in the chemistry of New Zealand plants.

1938. H. W. Williams, M.A., Litt.D., F.R.S.N.Z.—For researches in ethnology.

1939. J. A. Bartrum, M.Sc., F.R.S.N.Z.—For researches in geology.

#### AWARD OF THE HUTTON MEMORIAL MEDAL.

1911. W. B. Benham, M.A., D.Sc., K.B.E., F.R.S., F.R.S.N.Z.—For researches in New Zealand zoology.

1914. L. Cockayne, C.M.G., Ph.D., F.R.S., F.L.S., F.R.S.N.Z.—For researches in the ecology of New Zealand plants.

1917. P. Marshall, M.A., D.Sc., F.G.S., F.R.S.N.Z.—For researches in New Zealand geology.

1920. J. E. Holloway, L.Th., D.Sc., F.R.S., F.R.S.N.Z.—For researches in New Zealand pteridophytic botany.

1923. J. A. Thomson, M.A., D.Sc., F.G.S., F.R.S.N.Z.—For researches in geology.

1926. C. Chilton, M.A., D.Sc., LL.D., M.B., C.M., F.L.S., F.R.S.N.Z.—For his continuous researches on the amphipodous crustacea of the Southern Hemisphere.

1929. G. V. Hudson, F.E.S., F.R.S.N.Z.—For research in entomology.

1932. J. A. Bartrum, M.Sc., F.R.S.N.Z.—For researches in geology.

1935. G. H. Cunningham, D.Sc., F.R.S.N.Z.—For research in mycological botany.

1938. David Miller, Ph.D., M.Sc., F.R.S.N.Z., F.R.E.S., F.L.S.N.S.W.—For researches in entomology.

#### GRANTS FROM THE HUTTON MEMORIAL RESEARCH FUND.

1919. Miss M. K. Mestayer £10, for work on the New Zealand mollusca.

1923. Professor P. Marshall £40, for study of the Upper Cretaceous ammonites of New Zealand.

1927. Miss M. K. Mestayer £30, for research on brachiopoda and mollusca.

1928. Dr C. Chilton £50, for research on New Zealand and Antarctic crustacea.

1928. Dr H. J. Finlay £10, for research on New Zealand mollusca.

1932. Dr F. J. Turner £30, for geological expedition to south-west portion of Otago.

1932. Mr C. E. Christensen £25, for collecting hybrid plants at Hanmer.

1932. Mr L. C. King £20, for geological study of Tertiary rocks at Awatere Valley, Marlborough.

1932. Dr O. H. Frankel £25, for cytological research.

1932. Waitemata Harbour Survey Committee £25, for ecological survey of Waitemata Harbour.

1933. Mr G. M. Thomson £30, for preparation of illustrated catalogue of New Zealand crustacea.

1933. Mr K. M. Ruddall £5, for zoological research on Little Barrier Island.

1934. Mr L. C. King £25, for geological research in the Marlborough District.

1934. Messrs R. A. Falla and A. W. B. Powell £40, for research on the molluscan and bird fauna of the Sub-Antarctic Islands of New Zealand.

1934. Dr. W. R. B. Oliver £50, for assistance in publishing a monograph on the genus *Coprosma*.

1935. Dr P. Marshall £40, for purchase of microscope goniometer and field work in connection with mineral "tuhualite" of Mayor Island and the occurrence of the spheroidal granite of Karamea.

1935. Mr H. Service £4 10s, for geological research at the Bluff.

1936. Mr C. O. Hutton, £30, for field study of the Metamorphic and Intrusive rocks of the Lake Wakatipu region.

1939. Mr L. E. Richdale, £20, for expenses in connection with the ringing of birds.

#### AWARD OF THE HAMILTON MEMORIAL PRIZE.

1923. J. G. Myers, D.Sc.

1926. H. J. Finlay, D.Sc., F.R.S.N.Z., and J. Marwick, D.Sc., F.R.S.N.Z

1934. L. C. King, M.Sc., Ph.D.

1937. C. O. Hutton, M.Sc., Ph.D., F.G.S.

#### AWARD OF THE T. K. SIDEY SUMMER-TIME MEDAL AND PRIZE.

1933. Lord Rutherford of Nelson, O.M., D.Sc., F.R.S., F.R.S.N.Z.  
Special award to Mr G. V. Hudson, F.E.S., F.R.S.N.Z.

1936. Sir Leonard Hill, Kt., M.B., LL.D.

# THE ROYAL SOCIETY OF NEW ZEALAND, COUNCIL FOR 1938-39.

ESTABLISHED UNDER AN ACT OF THE GENERAL ASSEMBLY OF NEW ZEALAND INTITULED THE NEW ZEALAND INSTITUTE ACT, 1867; RECONSTITUTED UNDER THE NEW ZEALAND INSTITUTE ACT, 1903; CONTINUED UNDER THE NEW ZEALAND INSTITUTE ACT, 1908; AND RECONSTITUTED UNDER THE ROYAL SOCIETY OF NEW ZEALAND ACT, 1933.

## HONORARY PATRON.

His Excellency the Governor-General.

## COUNCIL.

### EX OFFICIO.

The Hon. Minister of Scientific and Industrial Research.

### GOVERNMENT REPRESENTATIVES.

Professor E. R. Hudson, B.Agr., B.Sc. (1939)  
Dr. E. Marsden, C.B.E., F.R.A.S., F.R.S.N.Z. (1939)  
Mr. B. C. Aston, F.I.C., F.R.S.N.Z. (1938)  
Dr. W. R. B. Oliver, F.L.S., F.R.S.N.Z. (1938)

### ELECTED BY MEMBER BODIES.

Auckland Institute .. ..	Mr G. Archey, M.A., F.Z.S., F.R.S.N.Z. Prof. H. W. Segar, M.A., F.R.S.N.Z.
Wellington Philosophical Society .. ..	Dr. H. H. Allan, M.A., F.L.S., F.R.S.N.Z. Mr. F. R. Callaghan, M.A., F.R.E.S.
Canterbury Branch of the Royal Society of New Zealand .. ..	Dr. F. W. Hilgendorf, M.A., F.R.S.N.Z. Mr. E. F. Stead
Otago Branch of the Royal Society of New Zealand	Dr. C. M. Focken. Mr. G. Simpson.
Hawke's Bay Branch of the Royal Society of New Zealand .. ..	Mr G. V. Hudson, F.E.S., F.R.S.N.Z.
Nelson Institute .. ..	Prof. Sir Thos. H. Easterfield, M.A., Ph.D., F.I.C., F.C.S., F.R.S.N.Z.
Manawatu Branch of the Royal Society of New Zealand .. ..	Mr. M. A. Elliott.

### CO-OPTED MEMBER.

Dr. P. Marshall, M.A., F.G.S., F.R.G.S., F.R.S.N.Z.

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PRESIDENT: Rev. J. E. Holloway, L.Th., D.Sc.

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HON. LIBRARIAN: Professor H. B. Kirk, M.A., F.R.S.N.Z.

HON. RETURNING OFFICER: Professor H. W. Segar, M.A., F.R.S.N.Z.

SECRETARY: Miss M. Wood, Royal Society of New Zealand, Victoria University College, Wellington, New Zealand.

MEMBER BODIES.

Name of Society.	Secretary's Name and Address.	Date of Affiliation.
Auckland Institute .. ..	Mr G. Archey, Institute and Museum, Auckland	June 10, 1868
Wellington Philosophical Society .. .. .	Mr J. T. Salmon, Dominion Museum, Wellington.	June 10, 1868
Canterbury Branch of the Royal Society of N.Z. . .	Mr E. W. Hullett, Wheat Research Inst., Chch.	October 22, 1868
Otago Branch of the Royal Society of New Zealand	Mr H. D. Skinner, Otago Museum, Dunedin.	October 18, 1869
Nelson Institute .. ..	Mr O. B. Pemberton, Cawthron Institute, Nelson.	December 20, 1883
Hawke's Bay Branch of the Royal Society of New Zealand .. . . .	Mr W. Goodwin Ball, Hawke's Bay Gallery and Museum, Napier.	March 31, 1875
Manawatu Branch of the Royal Society of New Zealand .. . . .	Mr S. J. Bennett, 25 Worcester Street, Palmerston North.	1935
Southland Branch of the Royal Society of New Zealand .. . . .	Mr J. H. Sorensen, Southland Museum, Invercargill.	October 31, 1939

FORMER MANAGER AND EDITOR

(Under the New Zealand Institute Act, 1867.)

1867-1903.—Sir James Hector. M.D., K.C.M.G., F.R.S.

PAST PRESIDENTS.

- 1903-04.—Hutton, Captain Frederick Wollaston, F.R.S.  
 1905-06.—Hector, Sir James, M.D., K.C.M.G., F.R.S.  
 1907-08.—Thomson, George Malcolm, F.L.S., F.R.S.N.Z.  
 1909-10.—Hamilton, Augustus.  
 1911-12.—Cheeseman, Thomas Frederick, F.L.S., F.Z.S., F.R.S.N.Z.  
 1913-14.—Chilton, Charles, M.A., D.Sc., LL.D., F.L.S., C.M.Z.S., F.R.S.N.Z.  
 1915.—Petrie, Donald, M.A., Ph.D., F.R.S.N.Z.  
 1916-17.—Benham, William Blaxland, M.A., D.Sc., F.R.S., F.Z.S., F.R.S.N.Z.  
 1918-19.—Cockayne, Leonard, C.M.G., Ph.D., F.R.S., F.L.S., F.R.S.N.Z.  
 1920-21.—Easterfield, Thomas Hill, M.A., Ph.D., F.I.C., F.C.S., F.R.S.N.Z.  
 1922-23.—Kirk, Harry Borrer, M.A., F.R.S.N.Z.  
 1924-25.—Marshall, Patrick, M.A., F.G.S., F.R.S.N.Z.  
 1926-27.—Aston, Bernard Cracroft, F.I.C., F.C.S., F.R.S.N.Z.  
 1928.—Thomson, J. Allan, M.A., D.Sc., F.G.S., F.R.S.N.Z. (Mr B. C. Aston reappointed May, 1928, *vice* Dr J. Allan Thomson, deceased).  
 1929-30.—Farr, Clinton Coleridge, D.Sc., F.R.S., F.P.S.L., F.R.S.N.Z.  
 1931-32.—Segar, Hugh William, M.A.  
 1933-34.—Speight, Robert, M.A., M.Sc., F.G.S., F.R.S.N.Z.  
 1935-36.—Williams, Rt. Rev. Bishop, M.A., Litt.D. (Canab & N.Z.), F.R.S.N.Z.  
 1937-38.—Evans, Prof. W. P., M.A., Ph.D., F.R.S.N.Z.

## HONORARY MEMBERS.

	Elected
Andrews, E. C., B.A., F.G.S., 32 Benelong Crescent, Bellevue Hill, Sydney	1934
Bragg, Professor Sir William, O.M., K.B.E., F.R.S., Royal Institution, 21 Albemarle Street, London, W.1	1923
Buck, P. (Te Rangī Hiroa), M.D., Ch.B. (N.Z.), F.R.S.N.Z., Bishop Museum, Honolulu	1934
Butler, Sir Edwin John, M.D., D.Sc., C.I.E., F.R.S., Secretary Agricultural Research Council, 6a Dean's Yard, Westminster, London, S.W.1	1930
Chapman, F., F.G.S., Commonwealth Palaeontologist, National Museum, Melbourne, Victoria	1932
Compton, Professor A. H., Ph.D., Sc.D., LL.D., University of Chicago, Chicago, U.S.A.	1934
Diels, Professor L., Ph.D., Director Botanic Garden and Museum, Dahlem, Berlin	1907
Einstein, Professor Albert, Princeton University, New Jersey, U.S.A.	1924
Fleming, J. A., D.Sc., Director of Department of Terrestrial Magnetism, 5241 Broad Branch Road, N.W. Washington, D.C., U.S.A.	1939
Fraser, Sir J. G., D.C.L., Trinity College, Cambridge	1920
Gatenby, J. B., M.A., Ph.D., B.Sc., D.Sc., Professor of Zoology and Comparative Anatomy, University, Dublin	1934
Haddon, Dr A. C., F.R.S., 3 Cranmer Road, Cambridge	1925
Hall, Sir A. D., K.C.B., M.A., D.Sc., F.R.S., Ministry of Agriculture, London	1920
Hill, Sir A. W., K.C.M.G., Sc.D., D.Sc., F.R.S., Director Royal Botanic Gardens, Kew	1928
Hopkins, Sir Frederick Gowland, O.M., M.A., M.B., D.Sc., University of Cambridge	1937
Jaggard, Dr T. A., Director of Volcanological Observatory, Volcano House, P.O., Hawaii	1927
Jeans, Sir James H., D.Sc., F.R.S., Cleveland Lodge, Dorking, Surrey	1929
Keith, Sir Arthur, M.D., F.R.C.S., LL.D., D.Sc., F.R.S., Buckston Browne Farm, Downe, Farnborough, Kent	1939
Malinowski, Bronislaw, Ph.D. (Cracow), D.Sc. (Lond.), Prof. of Social Anthropology, London School of Economics, London	1936
Marshall, Sir Guy A. K., C.M.G., F.R.S., 16 Cranley Place, London, S.W.7	1933
Mawson, Sir Douglas, B.E., D.Sc., F.R.S., The University, Box 498, Adelaide, South Australia	1920
Mortensen, Theodor, Ph.D., Director of the Department of Invertebrates of the Zoological Museum, Copenhagen	1927
Rivett, Sir David, K.C.M.G., M.A., B.Sc. (Oxon), D.Sc. (Melb.)	1937
Robinson, Sir Robert, The Dyson Perrins Laboratory, South Park Road, Oxford	1939
Russell, Sir John, D.Sc., F.R.S., Director of Rothamsted Experiment Station, Harpenden	1928
Seward, Professor A. C., Sc.D., F.R.S., Botany School, Cambridge	1928
Skottsberg, Professor C., D.Sc., Botaniska Trädgården, Göteborg, Sweden	1936
Wilckens, Dr. Otto, Bonn University, Bonn	1936
Woods, Henry, M.A., F.R.S., F.G.S., Sedgwick Museum, Cambridge	1920

FORMER HONORARY MEMBERS.

Elected		Elected	
Agardh, Dr J. G. . . . .	1900	Hochstetter, Dr Ferdinand von . .	1870
Agassiz, Professor Louis . . .	1870	Hooker, Sir J. D., F.R.S. . . .	1870
Arber, Dr E. A. Newell . . .	1914	Howes, G. B., F.R.S. . . . .	1901
Armstrong, Prof. H. E., F.R.S. .	1927	Huxley, Thomas H., F.R.S. . .	1872
Avebury, Lord, P.C., F.R.S. . .	1900	Klotz, Professor Otto J. . . .	1903
Baird, Professor Spencer F. . .	1877	Langley, S. P. . . . .	1896
Balfour, Prof. I. Bayley, F.R.S.	1914	Lindsay, W. L., M.D. . . . .	1871
Bateson, Professor W., F.R.S. . .	1915	Liversidge, Professor A., F.R.S. .	1890
Beddard, Dr F. E., F.R.S. . . .	1906	Lotsy, Dr J. P. . . . .	1927
Beneden, Professor J. P. van . .	1888	Lydekker, Richard, F.R.S. . . .	1896
Berggren, Dr S. . . . .	1876	Lyell, Sir Charles, F.R.S. . . .	1873
Bowen, Sir George Ferguson, G.C.M.G. . . . .	1873	Massart, Professor Jean . . . .	1916
Brady, Dr G. S., F.R.S. . . .	1906	McCoy, Professor Sir F. . . .	1888
Bruce, Dr W. S. . . . .	1910	McLauchlan, Robert . . . .	1874
Carpenter, Dr W. B., F.R.S. . .	1883	Massee, George . . . . .	1900
Chree, Dr Charles, F.R.S. . . .	1924	Masson, Sir D. Orme, F.R.S. . .	1928
Clarke, Rev. W. B., F.R.S. . . .	1876	Mellor, J. W., D.Sc., . . . .	1919
Codrington, Rev. R. H., D.D. . .	1894	Meyrick, E., F.R.S. . . . .	1907
Curie, Madame Marie . . . .	1927	Milne, J., F.R.S. . . . .	1906
Darwin, Charles, M.A., F.R.S. . .	1871	Mitten, William, F.R.S. . . .	1895
Darwin, Sir George, F.R.S. . . .	1909	The Most Noble the Marquis of Normanby . . . . .	1880
David, Professor T. Edgeworth, F.R.S. . . . .	1904	Mueller, Dr Ferdinand von, F.R.S.	1870
Davis, J. W. . . . .	1891	Muller, Professor Max, F.R.S. . .	1878
Davis, Professor W. Morris . . .	1913	Newton, Alfred, F.R.S. . . .	1874
Dendy, Dr A., F.R.S. . . . .	1907	Nordstedt, Professor Otto . . .	1890
Drury, Captain Byron . . . .	1870	Owen, Professor Richard, F.R.S.	1870
Ellery, R. L. J., F.R.S. . . .	1883	Pickard-Cambridge, Rev. O. . .	1873
Etheridge, Professor R., F.R.S. . .	1876	Richards, Rear-Admiral G. H. . .	1870
Ettingshausen, Baron von . . .	1888	Riley, Professor C. V. . . . .	1890
Eve, H. W., M.A. . . . .	1901	Rolleston, Professor G., M.D., F.R.S. . . . .	1875
Filhol, Dr H. . . . .	1875	Ross, Sir Ronald . . . . .	1929
Finsch, Professor Otto . . . .	1870	Rutherford, Lord, F.R.S. . . .	1904
Flower, Professor W. H., F.R.S. . .	1870	Sars, Professor G. O. . . . .	1902
Forbes, Professor A. H., F.R.S. . .	1878	Schmidt, Professor J. . . . .	1930
Goebel, Professor Dr Carl von . .	1901	Sclater, Dr P. L., F.R.S. . . .	1875
Goodale, Prof. G. L., M.D., LL.D.	1891	Sharp, Dr D. . . . .	1877
Gray, Dr J. E., F.R.S. . . . .	1871	Sharp, R. B., F.R.S. . . . .	1885
Gray, Professor Asa . . . . .	1885	Stebbing, Rev. T. R. R., F.R.S. .	1907
Gregory, Professor J. W., F.R.S.	1920	Stokes, Vice-Admiral J. L. . . .	1872
Grey, Sir George, K.C.B. . . .	1872	Tenison-Woods, Rev. J. E. . . .	1878
Gunther, Dr A., F.R.S. . . . .	1873	Thiselton-Dyer, Sir W. T., F.R.S.	1894
Haldane, J. S., M.A., M.D., LL.D., F.R.S. . . . .	1928	Thomson, Prof. Wyville, F.R.S. .	1874
Haswell, Prof. W. A., F.R.S. . . .	1914	Thomson, Sir Arthur . . . .	1928
Hedley, Charles . . . . .	1924	Thomson, Sir William, F.R.S. . .	1883
Hemsley, Dr W. Botting, F.R.S. . .	1913	Tillyard, R. J., F.R.S. . . . .	1935
		Wallace, Sir A. R., F.R.S. . . .	1885
		Weld, Frederick A. . . . .	1877

## FELLOWS OF THE ROYAL SOCIETY OF NEW ZEALAND.

## ORIGINAL FELLOWS.

(See *New Zealand Gazette*, 20th November, 1919.)

- †\*Aston, Bernard Cracroft, F.I.C., F.C.S.  
 ††Benham, William Blaxland, M.A., D.Sc., F.R.S., F.Z.S.  
 §\*Best, Elsdon.  
 †\*Cheeseman, Thomas Frederick, F.L.S., F.Z.S.  
 ††\*Chilton, Charles, M.A., D.Sc., LL.D., M.B., C.M., F.L.S., C.M.Z.S.  
 ††\*Cockayne, Leonard, C.M.G., Ph.D., F.R.S., F.L.S.  
 †\*Easterfield, Thomas Hill, M.A., Ph.D., F.I.C., F.C.S.  
 †\*Farr, Clinton Coleridge, D.Sc., F.P.S.L., F.R.S.  
 §Hogben, George, C.M.G., M.A., F.G.S.  
 †\*Hudson, George Vernon, F.E.S.  
 †Kirk, Harry Borrer, M.A.  
 ††\*Marshall, Patrick, M.A., D.Sc., F.G.S., F.R.G.S., F.E.S.  
 ††\*Petrie, Donald, M.A., Ph.D.  
 §\*Rutherford of Nelson, Lord, O.M., D.Sc., Ph.D., LL.D., F.R.S.  
 †Segar, Hugh William, M.A.  
 §\*Smith, Stephenson, Percy, F.R.G.S.  
 †\*Speight, Robert, M.A., M.Sc., F.G.S.  
 §Thomas, Algernon Phillips Withiel, K.C.M.G., M.A., F.L.S.  
 ††\*Thomson, Hon. George Malcolm, F.L.S., M.L.C.  
 ††Thomson, James Allan, M.A., D.Sc., A.O.S.M., F.G.S.

## FELLOWS ELECTED.

Date

Allan, Harry Howard, M.A., D.Sc., F.L.S.	..	..	..	1928
Andersen, Johannes Carl	..	..	..	1923
Archey, Gilbert, M.A., F.Z.S.	..	..	..	1932
Askew, Henry Oscar, M.A., Ph.D., D.I.C., F.I.C., F.N.Z.I.C., F.C.S.	..	..	..	1939
†Bartrum, John Arthur, M.Sc.	..	..	..	1928
*Benson, William Noel, B.A., D.Sc., F.G.S., F.R.G.S.	..	..	..	1926
§Brown, J. Macmillan, M.A., LL.D.	..	..	..	1925
*Buck, P. H. (Te Rangī Hiroa), M.D., Ch.B. (N.Z.)	..	..	..	1925
*Cotton, Charles Andrew, D.Sc., A.O.S.M., F.G.S.	..	..	..	1921
†Cunningham, Gordon Herriot, M.Sc., Ph.D.	..	..	..	1929
Curtis, Kathleen M., M.A., D.I.C., D.Sc., F.L.S.	..	..	..	1936
Denham, Henry George, M.A., D.Sc., Ph.D.	..	..	..	1933
Donovan, William, M.Sc., F.I.C.	..	..	..	1938
*Evans, William Percival, M.A., Ph.D.	..	..	..	1930
Finlay, Harold John, D.Sc.	..	..	..	1939
Henderson, John, M.A., D.Sc., B.Sc. (in Engineering)	..	..	..	1929
Hilgendorf, Frederick William, M.A., D.Sc.	..	..	..	1921
†*Holloway, John Ernest, L.Th., D.Sc.	..	..	..	1921
§Kidson, Edward, O.B.E., M.A., D.Sc.	..	..	..	1931
Laing, Robert Malcolm, M.A., B.Sc.	..	..	..	1922
§MacLaurin, James Scott, D.Sc., F.C.S.	..	..	..	1926
Macleod, Donald Bannerman, M.A., D.Sc.	..	..	..	1935
Marsden, Ernest, C.B.E., D.Sc., F.R.A.S.	..	..	..	1922
*Marwick, John, M.A., D.Sc.	..	..	..	1935
Miller, David, M.Sc., Ph.D.	..	..	..	1931
§Morgan, Percy Gates, M.A., F.G.S., A.O.S.M.	..	..	..	1922
*Oliver, Walter Reginald Brook, D.Sc., F.L.S., F.Z.S.	..	..	..	1927
Park, James, Hon.M.Inst.M.M.Lond., F.G.S.	..	..	..	1921
§Philpott, Alfred, F.E.S.	..	..	..	1930
Rigg, Theodore, M.A., M.Sc., F.I.C.	..	..	..	1932
*Skinner, Henry Devenish, M.A.	..	..	..	1927
Smith, William Herbert Guthrie	..	..	..	1924
§Sommerville, Duncan McLaren Young, M.A., D.Sc., F.R.S.E., F.R.A.S.	..	..	..	1922
§Tillyard, Robin John, M.A., D.Sc., F.R.S., F.L.S., F.E.S.	..	..	..	1924
§Turner, E. Phillips, F.R.G.S.	..	..	..	1936
Turner, F. J., D.Sc., F.G.S.	..	..	..	1938
†§Williams, Herbert Williams, Rt. Rev. Bishop, M.A.	..	..	..	1923

† Hector Medallist; † Hutton Medallist; † Past President; § Deceased.

## GENERAL INDEX.

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